SCOTTISH HOME DEPARTMENT

Marine Research
1956 No. 3

The Food and Feeding Habits of the Lemon Sole

By BENNET B. RAE, M.A., B.Sc., Ph.D.

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The Food and Feeding Habits of the Lemon Sole

INTRODUCTION

THE food of the lemon sole, *Microstomus kitt* (Walbaum), synonym *Pleuronectes microcephalus*, within the North Sea has been studied on several occasions, each time in the course of research into the food of fishes in general. Ramsay Smith (1888-91) examined the stomach contents of lemon soles caught in the Firth of Forth and Todd (1905 and 1907) investigated the food of a number of fish from grounds adjacent to the English coast between the Farne Islands and the Norfolk coast. In each case the fish dealt with were caught within a limited area and while in the former samples were obtained throughout the year, in the latter the material was procured mainly during the summer months. In neither instance was any account taken of the size of the fish or of the volumes of the different food types recognised.

COLLECTION AND TREATMENT OF MATERIAL

The need for a more detailed investigation of the food and feeding habits of the lemon sole arose from the discovery of local variations in the growth of the species, during a study of its life history and biology (Rae, 1939a). The material for the present work, consisting of about 5,000 stomachs, was collected off the Scottish coast chiefly on grounds which represent the main centres of distribution of the species in the North Sea and other home waters. Most of the stomachs were collected during the years 1937 to 1939 inclusive, when nearly every lemon sole caught on routine surveys by the research vessel *Explorer* was utilised, but collections by research vessels and from commercial sources extended intermittently over the period 1935 to 1955. Throughout the sampling an effort was made to cover as wide an area as possible while, at the same time, giving each locality its appropriate emphasis as regards its importance as a source of lemon soles. The incidence of the sampling shown in Figure 1 is satisfactorily similar to the distribution and concentration of the lemon sole in the North Sea and western Scottish grounds, so that the material collected may be regarded as thoroughly representative of the area. Stomachs were also collected throughout the entire year in order to study varying intensities of feeding.

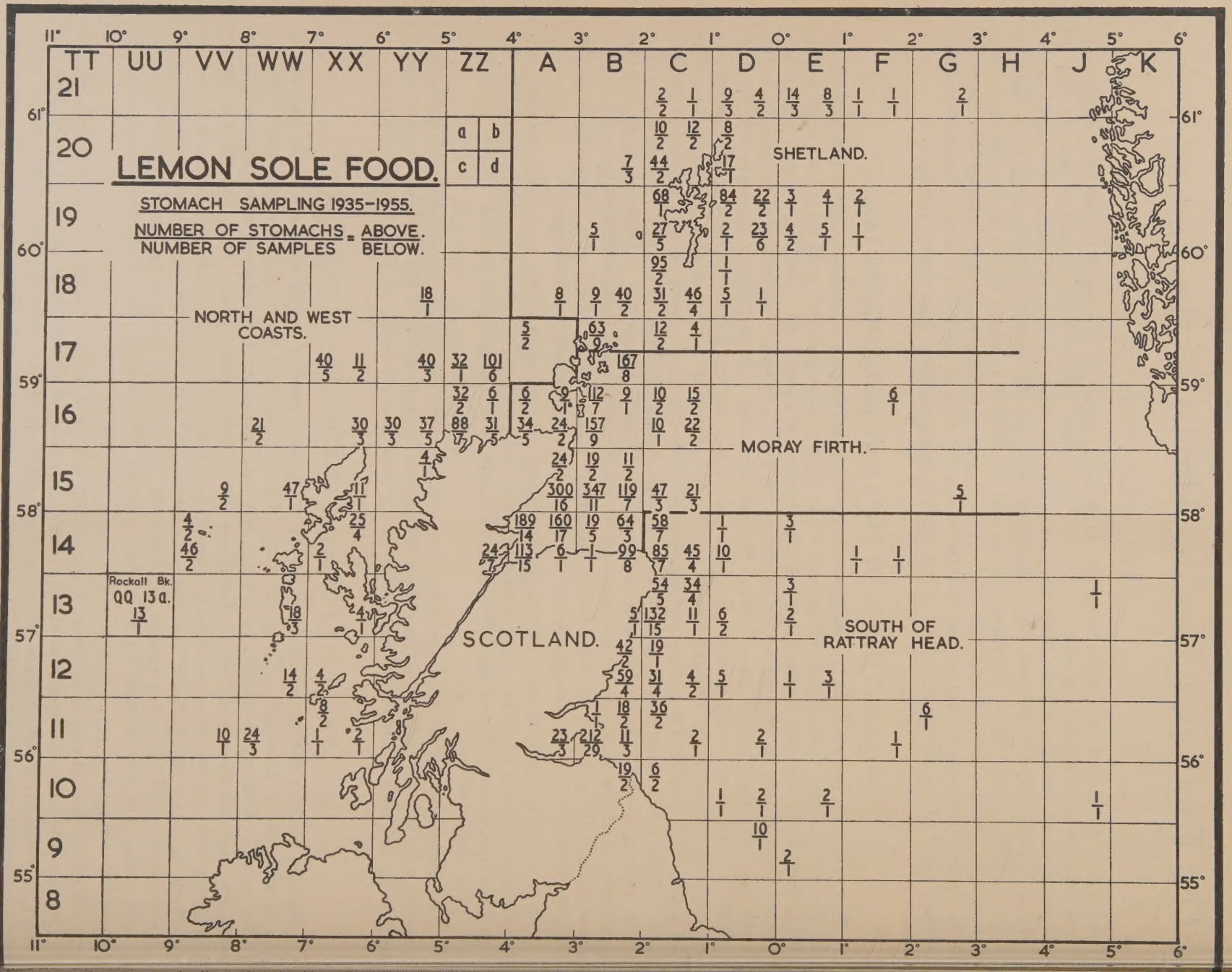
Most of the lemon soles were caught by otter trawl but several hundreds were taken by seine net. Stomachs and intestines were removed from the fish and preserved in weak formalin immediately the catch came on board. Most of the collections were made in 10 cm groups—less than 11 cm, 11-20 cm, 21-30 cm and 31-40 cm.

The examination of the condition of the stomachs and intestines and the identification of the stomach contents were carried out in the laboratory. Volumetric measurements of the stomach contents and of their main constituent food types were made at the same time by means of water displacement.

INTENSITY OF FEEDING THROUGHOUT THE YEAR

Ramsay Smith (1888-91) commented on the high percentage of empty stomachs in the samples of lemon soles, which he examined from the Firth of Forth, but drew no conclusions regarding variations in the seasonal intensity of feeding. In order to study this question the presence or absence of food in the stomachs and intestines were noted throughout the present investigations. Each month was treated separately and a distinction was drawn between samples from the areas where lemon sole growth is relatively good, i.e. in the North Sea south of latitude 59°15′N, and from areas where growth is poor, such as north of 59°15′N and west of the Shetlands the Orkneys and the mainland of Scotland. The results, which are presented in Table I, show marked differences in the numbers of empty stomachs throughout the year.

The occurrence of empty stomachs is a common feature in certain species of newly caught fish. In some cases this is due to regurgitation of the food, no doubt as a result of the upheaval in the trawl, in others to eversion of the stomach resulting from inflation of the swim bladder which occurs when some deep-water species are brought to the surface. In the lemon sole there can be no eversion of the


LEMON SOLE FOOD.
STOMACH SAMPLING 1935–1955.
NUMBER OF STOMACHS = ABOVE.
NUMBER OF SAMPLES = BELOW.
NORTH AND WEST COASTS.
SHETLAND.
MORAY FIRTH.
SCOTLAND.
SOUTH OF RATTRAY HEAD.
Rockall Bk.
QQ 13a.
TT UU VV WW XX YY ZZ A B C D E F G H J K
a b c d
11° 10° 9° 8° 7° 6° 5° 4° 3° 2° 1° 0° 1° 2° 3° 4° 5° 6°
61° 60° 59° 58° 57° 56° 55°
21 20 19 18 17 16 15 14 13 12 11 10 9 8

stomach since there is no swim bladder, and while regurgitation cannot be ruled out there is no evidence that it takes place. In this case the seasonal nature of the changes, together with the parallel condition of the intestines, clearly indicate some other explanation.

Table I, presenting the results of the investigation month by month, shows that the year may be divided into four periods according to the percentages of empty stomachs and intestines.

1. January and February. The percentages of empty stomachs and intestines are high but show a marked tendency to fall.

2. March to September. The percentages of empty stomachs and intestines are low with the extreme month at each end rather higher than the others.

3. October and November. The percentages are much higher than in the previous period and show a marked upward movement.

4. December. Practically all the stomachs are empty. At the same time nearly all the intestines are completely devoid of food material in any form. The short, shrunken, colourless appearance of the lemon sole intestines in December is in sharp contrast to their state throughout the greater part of the year, when they are long and swollen with digested or partly digested food.

These results demonstrate fairly conclusively that the variations in the numbers of empty lemon sole stomachs are due to seasonal differences in the feeding habits of the species. It is obvious that the main feeding period is from March to September, that feeding falls off sharply during October and November and that it ceases almost completely in December; thereafter the intensity of feeding increases rapidly throughout January and February.

Further support is lent to these conclusions by a series of weekly samples of stomachs from commercial vessels fishing local grounds over the period 27th November 1937 to 5th March 1938. The analysis of these samples is given in Table II. The almost complete cessation of feeding in December is again apparent together with the resumption of feeding in January and February.

At first the stomachs contained only small quantities of food, and frequently an isolated pellet of food passing through the contracted intestines was the sole indication that the fish had recently taken food. This seems to indicate that, even within the relatively small area covered by these weekly samples, feeding does not commence suddenly or simultaneously, but rather slowly and tentatively and that some fish after taking food may stop feeding again for a time. The variable proportions of empty stomachs and intestines during the first two months of the year also seem to support this view.

From general observation, it also seems likely that lemon soles on other grounds begin feeding in this way but the habit of temporarily ceasing to feed appears to persist throughout the entire feeding season, as is suggested by the regular occurrence of small numbers of fish with the alimentary canal quite empty.

Although the most complete data in Table I refer to the North Sea south of latitude 59°15′N, those for more northerly and westerly grounds show a similar trend as regards feeding. Furthermore, in a short study of the food of lemon soles at Faroe (Rae, 1939*b*), it has already been shown that 63% of the stomachs from that area were empty in February, 7% in the period April to August, 44% in October and November and 100% (a small sample) in December. The corresponding percentages for empty intestines were, February 37%, April to August 1%, October and November 22% and December 100%. In a sample of lemon sole stomachs from Faxa Bay, Iceland, at the end of July 1939, less than 5% were found to be empty while all the intestines contained food (Rae 1948). As these figures are remarkably similar to those for the Scottish area, it seems reasonable to assume that the seasonal feeding habits of the lemon sole in the North Sea are characteristic of the species wherever it occurs in the N.E. Atlantic.

FEEDING IN RELATION TO SPAWNING

Since Table I includes all sizes of lemon soles, it is necessary to consider them according to their size, age and maturity. Although age and maturity were not recorded during the collection of the stomachs, the division of the records into three 10 cm groups, 11-20, 21-30, and 31-40, may be accepted as roughly dividing the fish into young, middle-aged and old fish. At the same time the 11-20 cm group may be con-

sidered as composed entirely of immature fish in the faster growing areas while including a small pro- portion of mature individuals in localities where growth is slower. In both areas the 21-30 cm group includes immature and mature fish, the percentage of immatures being higher in the North Sea south of 59°15'N. The 31-40 cm group may be taken as consisting entirely of mature fish.

The records are arranged in 10 cm groups in Table III and illustrated in Figure 2 which give the

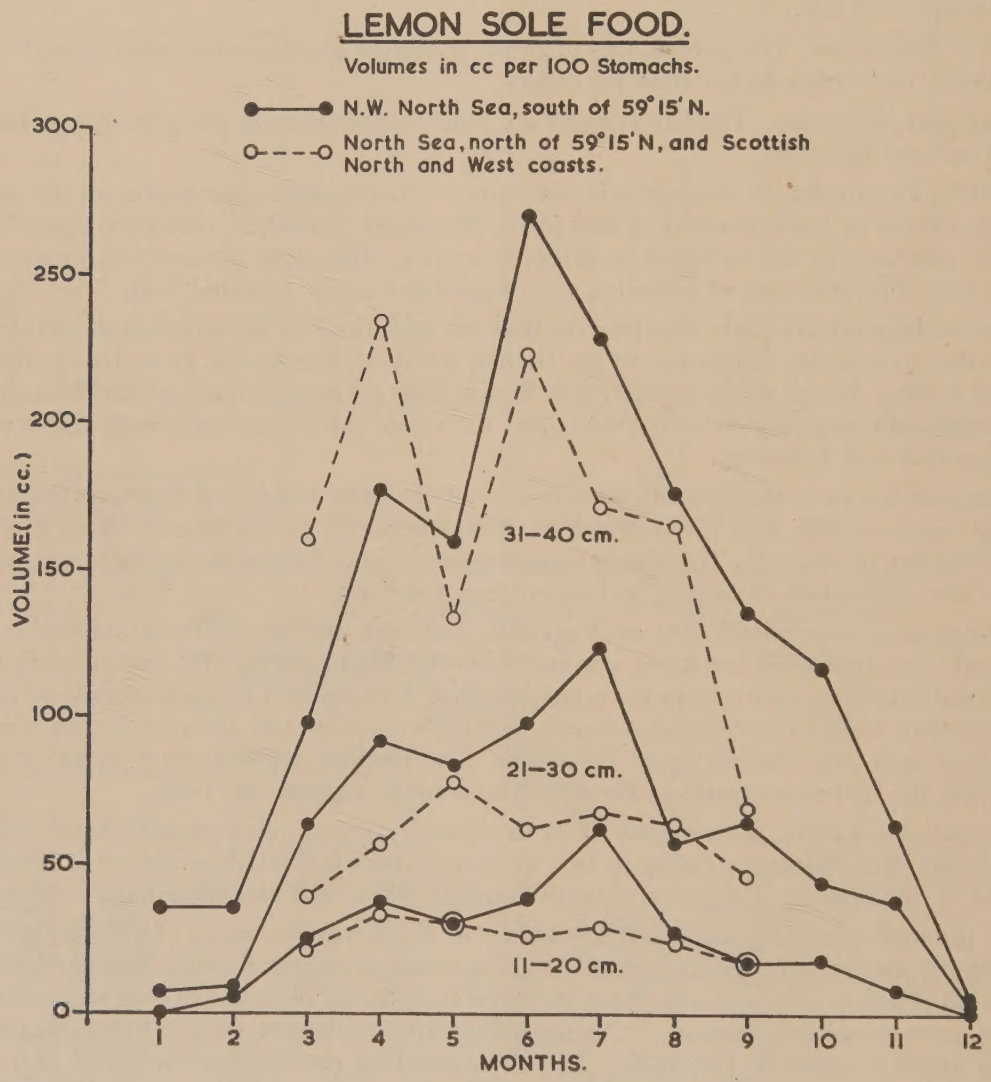


Fig. 2

calculated volumes of food per hundred stomachs for each month. In general these volumetric analyses of the stomach contents of the different size groups are in agreement with the results derived from Table as regards seasonal intensity of feeding. Moreover, they show that the conclusions are applicable to each size group and that the feeding cycle is, on the whole, not influenced by the condition of maturity or the age of the fish.

A feature which is common to all except one of the 6 graphs in Figure 2 is the temporary decrease in the volume of food per 100 stomachs in May. The fact that this decrease is greatest in the 31-40 cm group suggests that the cause is in some way connected with the adult or mature condition of the fish although its appearance, however slight, in immature fish of the 11-20 cm group tends to discredit this view.

In Scottish waters the spawning of the lemon sole extends over a long period. Commencing off the west coast at the end of March or the beginning of April, it rapidly spreads northwards to the Orkneys and Shetlands and then southwards into the western half of the central North Sea where it gradually draws to a close at the end of October or the beginning of November. In the north-western North Sea, however, which includes the principal centres of distribution of the species, spawning reaches maximum intensity in June, July and August, and thus coincides with the peak of the feeding intensity in the same area. On the northern and western grounds the height of the feeding season is, on the whole, slightly earlier but this is consistent with the rather earlier incidence of spawning on these grounds.

This coincidence of the main feeding season with the spawning season in the case of the lemon sole is in direct contrast with that of the plaice in which Todd (1915) found the fasting season, or the period of lowest feeding intensity, November to February, coincident with the spawning season. It should be noted, however, that the minimum feeding of plaice, as in most other species, is in mid-winter, whereas its spawning is unusually early. The common dab on the other hand resembles the lemon sole in its summer feeding and spawning habits. According to Hickling (1938) the reproductive organs of the Cornish pilchard reach their maximum development in April, May and June at the time when feeding is heaviest. Although this particular question does not always appear to have been considered by food investigators the main feeding season and the spawning season are separate in many species of food fishes and indeed involve in some instances quite distinct stock movements, e.g., haddock (Thompson, 1928), cod (Graham, 1923) and both spring and autumn spawning herring (Wood, 1932).

In the light of these observations, it is rather difficult to suggest any satisfactory reason for the temporary arrest of feeding in May. A possible explanation may be that a short-lived stoppage in feeding accompanies the commencement of spawning, but later the effect of spawning on feeding during summer is masked by the increased number of fish which, having completed spawning, resume feeding with renewed vigour.

The decline in the intensity of feeding of lemon soles during the winter months occurs at the time when catches of this species by commercial vessels are at their lowest. Conversely, the greatest catches are obtained during the summer by exploiting the shoals of fish concentrated for spawning. This is characteristic of all the recognised lemon sole grounds in the North Sea, at Faroe and at Iceland. It is difficult to suggest the precise reason for the pronounced decline in the feeding which appears to be more marked than in the case of any of the other flat fishes studied in Scottish waters. The relatively poor catches of lemon soles during the winter months indicate a dispersal of the shoals, and the complete absence of food from the stomachs of such a high percentage of the fish during December suggests that the fish assume a quiescent mode of life by withdrawing to lie in hollows or in the sand or gravel in a state resembling hibernation. This explanation, however, does not appear entirely satisfactory, since the decline in feeding is already apparent in September when the sea temperatures in the north-western North Sea are at their highest level for the whole year. Under such conditions the metabolic rate and the food intake of the fish might have been expected to remain high. Moreover, the almost complete stoppage of feeding occurs in December, some considerable time before the temperatures reach their lowest level for the year, in February and March. It has already been noted that the resumption of feeding is well under way by March. The answer to this problem may therefore depend on a more thorough understanding of the physiology and metabolism of marine fishes under natural conditions.

GENERAL FEATURES OF THE STOMACH CONTENTS

In spite of the action of the gastric fluids on the stomach contents, particularly on organisms lacking a resistant skeleton, little difficulty was experienced in identifying most of the different food types. Indeed, although the contents of the intestines have not been included in the food analysis, many of the individual items remained recognisable throughout the length of the long intestine. Thus many polychaete worms, crustaceans, small molluscs and echinoderms could still be identified, even in some cases at the point of being excreted. The amount of unrecognisable material in the stomachs has, therefore, proved remarkably small, and on an average has seldom exceeded 5% of the total contents.

Frequently it has been impossible to ascertain more than the general type of the food but, wherev possible, the family, genus and species have been identified. More attention has naturally been given the principal food types than to subsidiary forms such as nemerteans, ascidians and chitons, the individu species of which have not been identified.

The contents of the stomachs varied numerically from a single animal or part of an animal to as ma as fifty or more organisms. The latter occurrence, however, is rare and appears to be confined to a co paratively small number of species. These include a few of the smaller polychaete worms such as *Hydroi norvegica, Sabellaria spinulosa, Ampharete grubei, Onuphis conchylega* and the brittlestars *Ophiura albida* and *affinis*.

Although some stomachs contain only one type of food, for example the tentacles of terebellid worm or some anthozoan, most of them contain more than one type. Occasionally, stomachs contain a variety organisms which serves to emphasise the catholic taste of the lemon sole when a variety of food is prese on the grounds or when the more favoured types are less plentiful. The following examples will demonstra the variable nature of the food of some individual fish.

a. The first, caught 8 miles off Aberdeen, was found to be feeding on representatives of five differe families of polychaetes—Sabellariidae (head and thorax of one *Sabellaria spinulosa*), Terebellida (pieces of several *Lanice conchilega*), Maldanidae (segments of *Clymene robusta*), Ampharetidae (tw *Ampharete grubei*) and Phyllodocidae (one *Phyllodoce lineata*). A few small amphipods, one nemertea and fragments of colonial ascidians were also present.

b. The second, caught off the Firth of Forth, contained parts of worms from three polychaete familie *Terebellidae* (one *Thelepus cincinnatus*) Nereidae and Aphroditidae, one hermit crab, two amphipod one nudibranch, two specimens of *Velutina laevigata* and part of a *Cerianthus*.

c. The third fish, from Shetland grounds, was feeding on representatives of four polychaete families— Terebellidae (tentacles and other parts of *Thelepus cincinnatus*), Aphroditidae (one very small specime Phyllodocidae (head of one *Eulalia viridis*) and Eunicidae (head and thoracic region of one *Onuph conchylega*). Also included were one gephyrean, part of a decapod crustacean, six amphipods (includi three caprellids and one *Ampelisca*), five *Ophiura affinis* and pieces of hydroid colonies.

The results of the food analysis are presented in Tables IV, V, VI and VII and in an appendix whi gives a list of the individual species identified.

In Tables IV (frequency percentages of the different food types) and V (volumetric analysis) the ma food types are considered on the basis of (*a*) growth areas, the boundaries of which are outlined in figu 1, and (*b*) size groupings of the fish. These tables, which are illustrated by Figures 3 and 4, include resul obtained from March to September inclusive, because these are the main feeding months and also becau records from northern grounds are almost entirely confined to this period. Table VI gives a more detail account of the food in each statistical rectangle or group of rectangles into which the whole area is co veniently divided for scientific purposes (Figure 1). In some localities, where differences in the depth in the food types indicate the necessity for separate treatment, rectangles have been subdivided as in th Firth of Forth and in the inner Moray Firth. Table VII summarises these results according to four growt areas.

IDENTIFICATION OF THE FOOD TYPES

Lemon sole food includes five main types—Polychaeta, Crustacea, Mollusca, Echinodermata an Coelenterata—and six subsidiary types—Nemertea, Gephyrea, Ascidiae, Polyzoa, Pisces and Algae.

Polychaeta

Of the main types the Polychaeta exceed all the others both numerically and volumetrically. This characteristic of each of the four regions named in Tables IV and V although in certain localities withi these regions other types sometimes rival the Polychaeta or even surpass them in importance. For exampl on certain Moray Firth grounds the anthozoan, *Cerianthus*, is the most important food type, especiall to the larger fish.

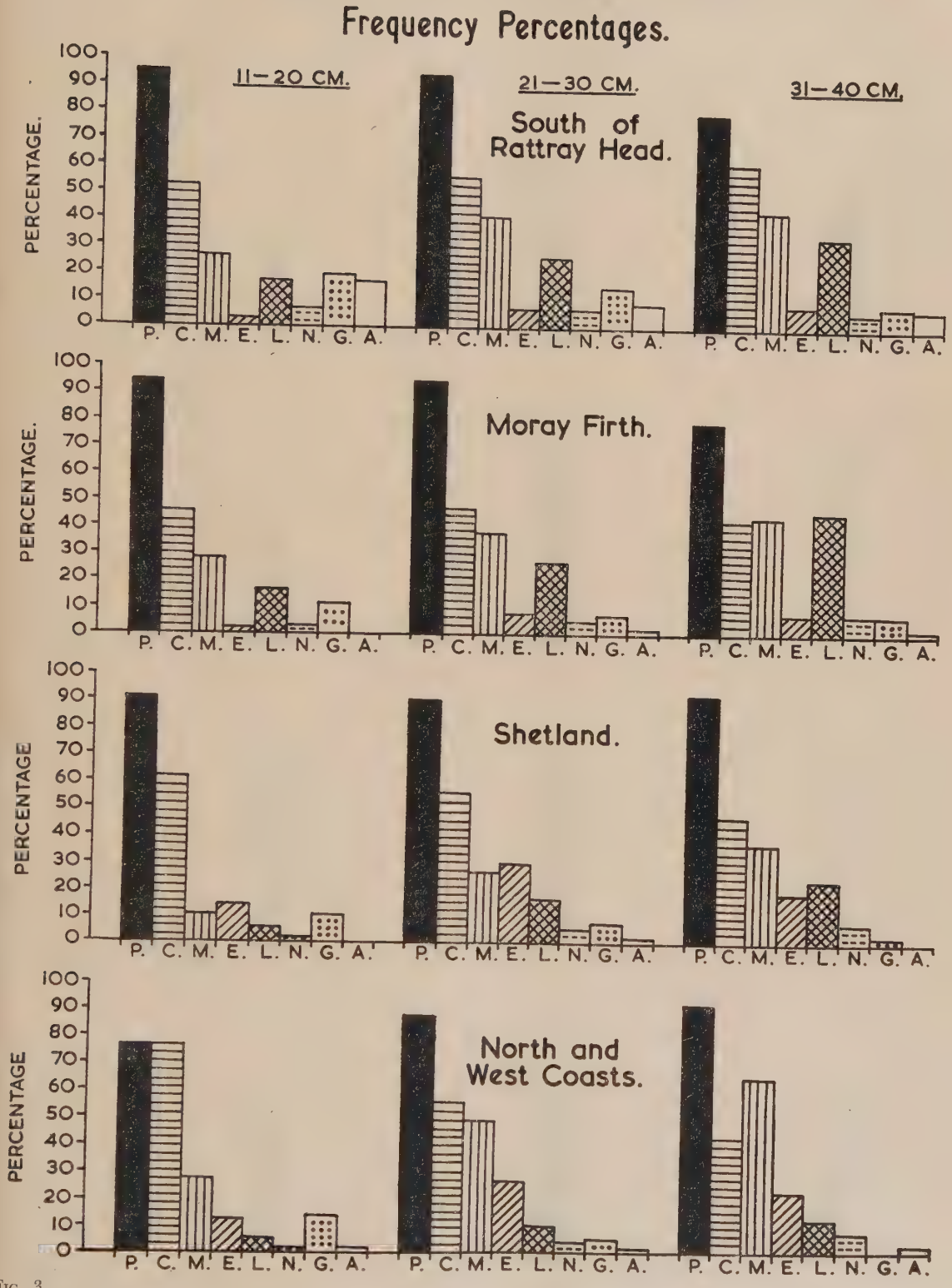


FIG. 3

Key P. Polychaeta C. Crustacea M. Mollusca E. Echinodermata
L. Colenterata N. Nemertea G. Gephyrea A. Ascidiae

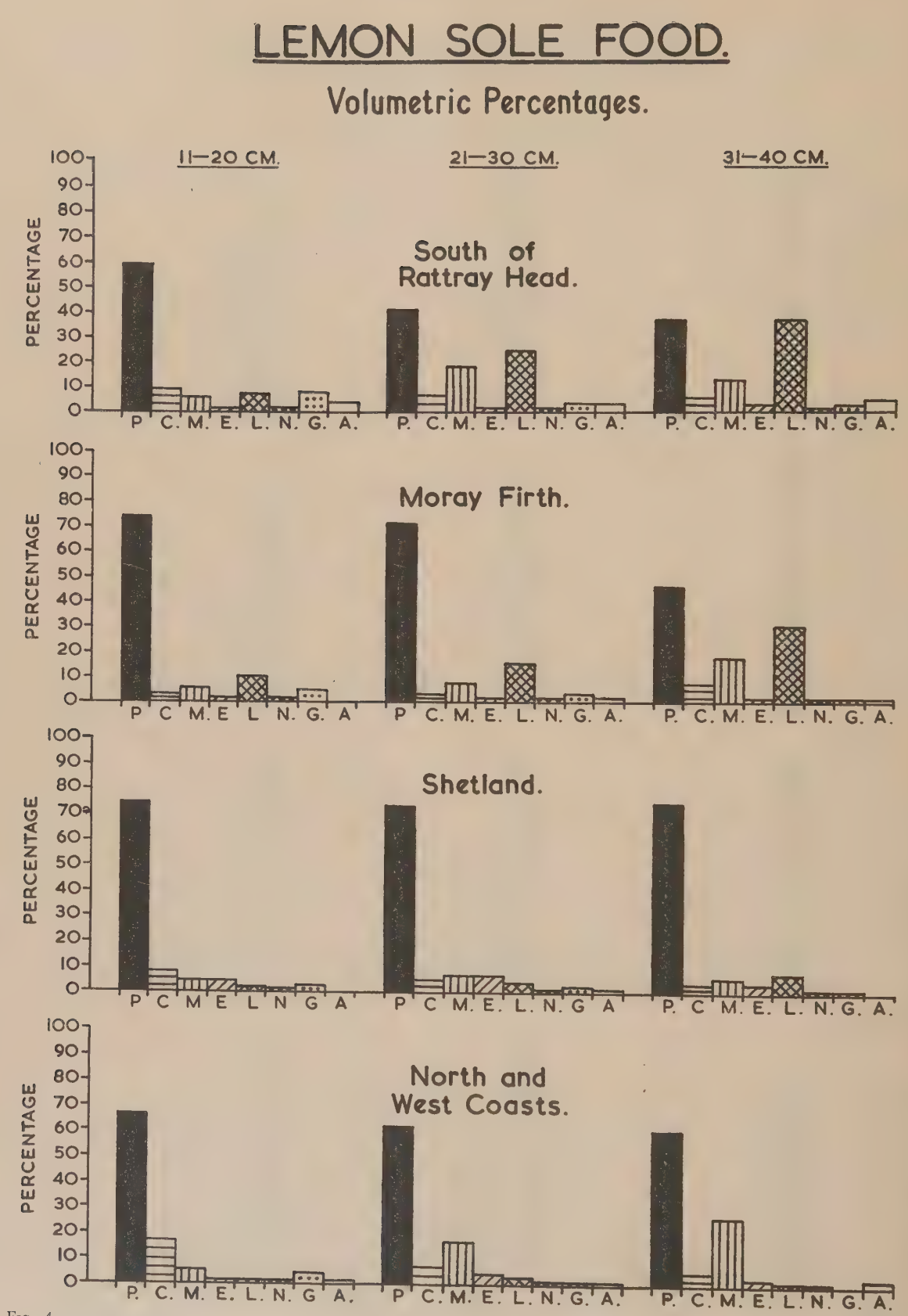


FIG. 4

Key P. Polychaeta C. Crustacea M. Mollusca E. Echinodermata
L. Colenterata N. Nemertea G. Gephyrea A. Ascidiae

No fewer than thirteen families of sedentary and nine families of errant polychaetes are represented in the food list (Table VI). Among the sedentary worms the Terebellidae, Serpulidae and Sabellariidae are the most prominent families in the stomach contents, while the Sabellidae, Maldanidae, Oweniidae and Ampharetidae, though individually of less importance, nevertheless collectively form an important part of the lemon sole diet. The remaining six sedentary families—the Cirratulidae, Capitellidae, Amphictenidae, Chloraemidae, Chaetopteridae and Spionidae—appear but rarely in the stomachs.

The Terebellidae are by far the most important polychaete family in the lemon sole food, both by numbers and by volume. Although nearly a dozen different species have been recognised in the stomachs, the family is mainly represented by two species, *Lanice conchilega* and *Thelepus cincinnatus*. The former occurs over a wide area, in depths varying from a few metres to over 150 metres, while the latter is more restricted in distribution to grounds lying within the deeper section of the same depth range. This family ,although consumed by all sizes of lemon soles, is eaten particularly by the larger fish, perhaps because of the large size to which many of the individual worms grow. The Terebellidae, from their occurrence in the stomachs appear to be very numerous in the Moray Firth and especially to the east of the Pentland Firth and the Orkneys. On the latter grounds they are represented in 95% of the stomachs containing recognisable food, often by their tentacles alone. On certain Shetland grounds they are also present in considerable concentration.

The Serpulidae are numerous in the stomachs from each of the four areas but attain their maximum south of Rattray Head. The small size of the individual species in this family renders them particularly suitable to the smaller lemon soles. The same characteristic also results occasionally in large numbers being eaten by individual fish although this is not a common feature of lemon sole feeding.

The Sabellariidae are represented by the single species, *Sabellaria spinulosa*, which occurs in its greatest density off the Aberdeenshire coast. Southwards to the English coast, where Todd found it in lemon sole stomachs, it occurs less frequently and in the Moray Firth it becomes scarce, while north of 58°30′N it has been found in only two fish from a position off the north coast of Scotland. Figure 5a illustrates the distribution of this species as determined from its occurrence in lemon sole stomachs. The distribution of this family appears more localised than that of any of the other major families of polychaetes in the lemon sole diet.

The Sabellidae are eaten throughout the Scottish area but are slightly more strongly represented in the stomachs from the Minch and inshore waters of Orkney and Loch Eriboll. The feathery tentacles of some members of this family are frequently eaten without a trace of the head and adjacent segments. On the other hand, it is not unusual to find a large portion of individual worms in the stomachs together with their muddy, leathery tube, although the presence of worm tubes in the stomachs is rather unusual.

The Maldanidae are generally present in the stomachs in fragmentary condition, which renders their identification troublesome. This family and the Oweniidae, represented by the single species, *Owenia fusiformis*, attain their greatest importance on Moray Firth grounds. The Ampharetidae are on the whole small forms with a more coastal distribution and showing maximum concentration locally in the Dornoch Firth and in the Firth of Forth.

Among the errant Polychaeta the Aphroditidae, Phyllodocidae and Eunicidae occur most frequently in the lemon sole food. The Nereidae and Syllidae appear much less frequently while four families, Hesionidae, Nephthydidae, Sphaerodoridae and Glyceridae are of rare occurrence.

The majority of the Aphroditidae eaten by lemon soles are small forms which rapidly break up in the stomachs thus adding to the difficulties of recognition. Many of these small worms, however, appear to belong to the genus *Harmothoe*. Occasional large worms are encountered in fragments measuring from about one half to one centimetre which give the impression of having been bitten into sections. It is interesting to note, however, that *Aphrodite aculeata* has never been found in the stomachs, no doubt because it is rather large for the small-mouthed lemon sole and perhaps also because its habits differ from those of polychaetes which form part of the lemon sole diet. The Aphroditidae are most numerous in stomachs from the north-west and west coast grounds; they gradually become scarcer in passing through the Shetland and Moray Firth areas to south of Rattray Head where they are of minor importance.

The Phyllodocidae are also frequently represented by small forms. This family reaches its frequency peak in the Moray Firth.

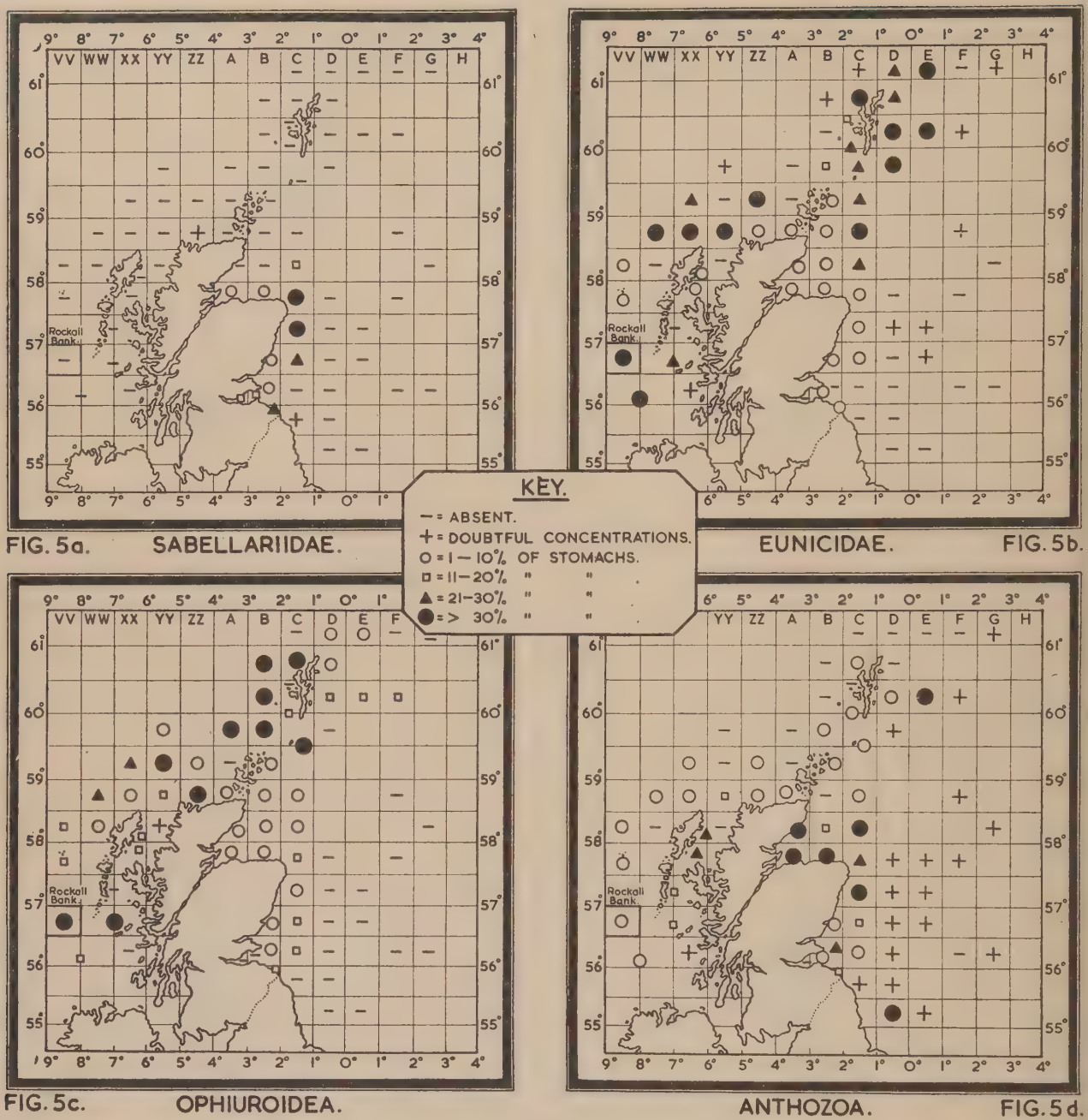


Fig. 5—Frequency of Occurrence of Four Sub-types in Food of Lemon Sole.

Unlike the two errant families already mentioned, the Eunicidae are seldom represented by small forms. Species of the two genera, *Hyalinoecia* and *Eunice*, attain a larger size so that volumetrically they are of greater importance than the other errant families. Another member of this family, *Onuphis conchylega* is invariably represented in the stomachs by the head and thoracic region. This species is one of the few organisms in the lemon sole food list which may occasionally be consumed in quantity by individual fish. The Eunicidae, as an item in the food of the lemon sole, are largely confined to the Shetland and north-west and west coast regions (Figure 5b).

The members of the Nereidae eaten by lemon soles are usually worms of appreciable size but the Syllidae are small and unimportant.

Crustacea

The crustaceans represented in the lemon sole food are mainly Amphipoda and Decapoda. The

frequency percentages of the Amphipoda increase steadily from grounds south of Rattray Head to a maximum off the north-west and west coasts. In general, stomachs seldom contain more than a few amphipods except in the latter region where they sometimes are present in large numbers. The frequency with which this type of food appears in the stomachs tends to exaggerate its importance, and to appreciate its real value in relation to the other food types it is essential to consider the volumetric figures for crustacea as a whole and to realise that only a small proportion of the total is due to Amphipoda. Most of the amphipods found in the stomachs belonged to the Ampeliscidae and Caprellidae.

Of far greater importance, especially from the point of view of quantity, are the Decapoda. These are most numerous on grounds to the south of Rattray Head, where they occur in nearly 30% of the stomachs. The Decapoda also show a high frequency of occurrence on north-west and west coast grounds where they consist largely of larval and young forms; whereas the individuals eaten by lemon soles off the Scottish east coast have a greater average age and size. Lemon soles prey upon a variety of decapods but the Eupaguridae are by far the most prominent sub-type in the stomachs. *Galathea* and *Hyas* follow in order of importance but it is of interest to note that these genera nowhere in Scottish waters attain the position of importance which they occupy in the food of lemon soles at the Faroes (Rae, 1939b). Other Decapoda such as *Portunus*, *Porcellana*, *Ebalia*, *Atelecyclus*, *Pandalus*, *Crangon* and *Nika* are much less frequent or even rare.

Other crustaceans, represented by Isopoda (larval and adult forms of *Gnathia*, etc.) Cirripedia (mostly pieces of *Balanus*), Copepoda (both parasitic and bottom forms), are not uncommon though unimportant quantitatively; Mysidacea, Euphausiacea and Pycnogonidae rarely appear in the food.

Mollusca

Among the Mollusca the Gasteropoda are outstanding as lemon sole food. Owing to the fragmentary condition of the larger forms little identification has been possible, although some success has been achieved in this connection with some of the smaller forms. Nudibranchs are readily recognised as a class but their rapid disintegration has prevented detailed identification. Larger Gasteropoda are more frequently consumed on southern than on northern grounds while small forms complete with shells are more numerous in the stomachs collected off Shetland and on the north and west coasts.

Another group of the Mollusca finding favour with lemon soles, especially in certain localities within the areas of good growth, is the Lamellibranchiata. Here, too, however, the fragmentary nature of the food prevents identification of the individual species except in a few instances, where young forms are eaten complete with shell. Two classes of Mollusca, Cephalopoda and Scaphopoda appear but rarely in the food of the lemon sole. At least two of the cephalopod records consist of ova of small Octopoda with the embryos in an advanced stage of development.

Echinodermata

In Scottish waters one class, the Ophiuroidea or brittlestars, predominates in the echinoderm food of lemon soles. They are invariably juvenile or young forms of a small size measuring from 2 to 4 millimetres across the disc. This group includes one or two of the few animals which may occur in fairly large numbers in individual stomachs. Unlike some types referred to, the resistant nature of the brittlestar skeleton greatly facilitates identification. The brittlestars are particularly well represented on Shetland and north-western grounds (Figure 5c). The four remaining classes of echinoderms, Echinoidea, Asteroidea, Crinoidea and Holothurioidea, are seldom eaten by lemon soles on Scottish grounds but the last-named class is of some importance at the Faroes.

Coelenterata

Excluding a few unusual records of pieces of Alcyonaria the Coelenterata are represented in the lemon sole food list by two types—Anthozoa and Hydroida. The Anthozoa form an important item in the Moray Firth and to the south of Rattray Head where they sometimes equal, or even on occasion surpass, the Polychaeta from the point of view of volume. Owing to the soft structure of these animals and the lemon sole's method of feeding, complete specimens are rarely found in the stomachs. Identification is thus rather difficult but one genus, Cerianthus, is recognised as providing the bulk of the Anthozoan

material in the areas referred to above. This type also occurs fairly frequently in lemon soles caught in the Minch (Figure 5d).

The Hydroida are, on the other hand, an unimportant group. Many of the records consist of small branches of colonial forms often giving the impression of their having been consumed accidentally along with other food. Several stomachs, however, have been found packed full of this type thus disproving the possibility of chance on every occasion.

Subsidiary Types

Gephyrean worms are eaten over a wide area but more commonly in certain inshore localities of the Firth of Forth and the Moray Firth, for example, in Burghead Bay, where they are fairly abundant. Without exception these worms were all found to be sipunculids with *Phascolion strombi* the commonest individual species. The Nemertea are most numerous south of Rattray Head, although overall they occur less frequently in the stomachs than the Gephyrea. The size of the individual worms preyed upon varies considerably from quite large specimens, usually incomplete and in fragments, to small forms of a few millimetres in length. Lemon soles also prey upon ascidians, both solitary and colonial forms. The highest frequencies of these animals occur in the stomachs from the Aberdeenshire coast southwards. Larval forms are also devoured in large numbers by the smaller fish in Aberlady Bay and to a less degree at other positions in the Firth of Forth. The Polyzoa are quite unimportant and are represented in the food by small fragments only.

Considering the frequency with which fish appear in the food of the majority of other fishes, the scarcity of this type in the stomachs of lemon soles is remarkable. In about five thousand examined only forty-four contained fish. It is also surprising that twenty-two of these records occurred in one sample of eighty-four stomachs from the vicinity of Smith Bank in the Moray Firth in June, 1938. The fish preyed upon on this occasion were sandeels. On other occasions, at the same and at neighbouring positions, not a single sandeel was found in the lemon sole stomachs although other species such as whiting, haddock and plaice were often feeding heavily on them. The remaining twenty-two records, which included sandeels, gobies, larval flatfishes and fish ova, occurred chiefly as isolated cases throughout the area covered by the investigations.

Small pieces of marine algae appear regularly in the stomach contents from certain localities, notably from the grounds immediately to the east of the Orkneys. The manner of their occurrence suggests consumption with other kinds of food such as Terebellid tentacles, yet one particular stomach, found gorged with the terminal portions of *Polysiphonia* fronds, seems to indicate that the presence of algae in the diet of lemon soles is not always fortuitous.

VOLUMETRIC ANALYSIS OF THE FOOD

Volumetric measurements of the stomach contents have already been considered in earlier sections (Tables I, II and III) in which the rise and fall in the intensity of feeding of the species has been traced throughout the year. Table V, illustrated by Figure 4, presents these data in greater detail from various other aspects including the growth areas, the size of the fish and the various food types.

The volumetric data confirm the importance of Polychaeta in all four areas. In each area and in each size group the volume of polychaete material in the stomachs far exceeds that of any of the other food types except in one instance. This exception occurs on grounds south of Rattray, where the volume of Anthozoan material, mostly *Cerianthus,* in the stomachs of the larger fish (31-40 cm group) equals the quantity of polychaetes.

In contrast to the relatively high frequency figures for Crustacea the volumes of this type are comparatively low. This seems to be due to the small size of most crustaceans eaten by lemon soles and particularly to the numerous instances in which the type is represented by one or two amphiphods of negligible volume. The value of Mollusca in the diet of the lemon sole is reflected in the high volume which this type occupies in the stomachs of the 31-40 cm size group. The echinoderms, although appearing fairly frequently in the medium-sized and large fish on Shetland and other northern grounds, are

overall the least important quantitatively of the five main food types. The coelenterates, on the other hand, are of greater importance volumetrically than the frequency figures indicate and from the Moray Firth southwards this type provides a frequent alternative to polychaetes in the diet of the bigger fish.

Although gephyreans and ascidians are of some limited importance locally to the south of Rattray Head, the six subsidiary types referred to on page 14 as a whole are of little consequence from a volumetric standpoint.

DISCUSSION OF RESULTS

Comparison of the Food in Different Areas

This aspect of the lemon sole food investigations has already been discussed in the last two sections. It has also been considered in an earlier paper on the food and growth of the species (Rae, 1939*c*). The main features may be summarised as follows:

In proceeding northwards along the Scottish east coast to the Shetlands a series of zones are encountered in which the growth of lemon soles becomes progressively poorer. This change in the growth is accompanied by gradual, but nevertheless significant, changes in the composition of the food. A slight fall in the frequency with which Polychaeta are eaten is noticeable in passing from zones of good growth to zones of poor growth but even more remarkable is the change in the frequency with which the various families of the Polychaeta are eaten. In general these show a partial replacement of sedentary worms on southern grounds by errant types on northern and north-western grounds (Table VII). Among the Crustacea the fairly high representation of small Decapoda on grounds south of Rattray Head is largely replaced by Amphipoda, particularly in the north-western area. Moreover such Decapoda as do occur in the stomachs from the north-western area are largely young or larval forms. The change in the molluscan type of food is also of the nature of a replacement of one subtype by another. From preying on the larger gasteropods (including nudibranchs) and lamellibranchs, in the zones of good growth lemon soles in the two northern regions, where growth is poor, become more dependent on small, shelled forms, such as chitons and small Patellidae and Fissurellidae. The two remaining principal food types, the echinoderms and the coelenterates, show an interesting reversal of position as regards their importance in the various areas. From a frequency of 5% in the Moray Firth and other east coast grounds small ophiuroids increase to 20% round the Shetlands and off the north and west coasts. The Anthozoa, on the other hand, decline from an overall frequency of 22% in the Moray Firth and on southern grounds to 6% on northern and western grounds (Table VII). Among the subsidiary food types the gephyreans and nemerteans are represented on all grounds but are slightly more numerous in the stomachs from the areas of good growth. The ascidians, with few exceptions, are mainly eaten on grounds south of Rattray Head, especially off the Aberdeenshire coast, where they have been recognised in 18% of the stomachs (Table VI).

Reference to Tables III and V shows that over the main feeding period, March to September, a decline in the average volumes of food consumed by each 10 cm size group is evident in passing from the areas of good growth (south of Rattray Head and in the Moray Firth) to the areas of poor growth (Shetland and the Scottish north and west coasts). Off the north and west coasts this decline is not so pronounced as in the Shetland area, presumably because most of the data for this area were obtained at the height of the feeding season (April to July), thus giving figures which, if regarded as applying to the period March to September, are somewhat misleading.

It has been concluded, therefore, that differences in the rate of growth of lemon soles from one area to another are largely due to differences in the types and quantities of the food available. Similar conclusions have been reached regarding the species at Faroe (Rae, 1939*c*).

Comparison of the Food of the Different Size Groups

The tabulation of results from the four areas in Tables IV and V (see also Figures 3 and 4) also provides a means of comparing the food preferences of the three size groups. Before doing so, however, it is of interest to consider the food examination of 95 lemon soles, ranging from 6 to 10 cm in length, which were preserved for other purposes over a longer period than that of the present investigations. These fish, though among the smallest taken on the sea floor by means of the otter trawl, do not necessarily

represent the youngest bottom forms in every case, since differences in the growth rate must be tak into account. The results are given in Table VIII, which shows that, although the number of stomac examined was small and the number of food types accordingly smaller than in Table VI, their foo includes the same groups as that of the larger fish.

It has already been shown that the food of the lemon sole consists predominantly of Polychaet Tables IV and V, however, clearly show a decline in both frequencies and volumes of this type food in passing from the smallest fish to the largest. This decline is less prominent on the grounds whe growth is poor and seems to be due to the absence or scarcity of alternative food types in these are Small worms such as the Serpulidae and Ampharetidae are more readily taken by the smaller lemo soles, while large worms such as the Terebellidae are more suitable for and thus presumably preferred b the larger fish.

A decline is also observed in the consumption of Crustacea with increasing size of lemon soles. A exception to this is found in the area south of Rattray Head, where the frequency figures for Crustace show a rise with each size group. Several features of the crustacean food help to provide an explanatio of this apparent contradiction. In the first place the smaller lemon soles eat more amphipods than do th larger fish. Secondly the consumption of amphipods decreases from a maximum off the north-west Scotland through the Shetland and Moray Firth regions to a minimum south of Rattray Head. Thirdl the larger lemon soles show a preference for larger crustaceans such as decapods, and lastly the decapod attain their greatest importance as lemon sole food south of Rattray Head. What at first sight appea as a contradiction to the general rule is therefore due to the gradual replacement of amphipods b decapods. In the other areas the supply of suitable decapods is apparently insufficient to counteract th fall in the frequency figures for crustacea caused by the declining interest in amphipods.

In contrast to the first two food types the Mollusca show a conspicuous rise in frequency and volum with increasing size of lemon soles. This has also been observed in investigations on the food of the speci at Faroe, where the 31-40 cm group and also a larger group, 41-50 cm, feed heavily on lamellibranch Small gasteropods such as Chitonidae, small Patellidae and Fissurellidae are more readily eaten by sma and medium-sized fish while nudibranchs and lamellibranchs are preferred by the larger fish.

The echinoderms, mainly represented by young brittlestars, attain their highest frequencies an volumes in the stomachs of the 21-30 cm group and in a slightly less degree of the 31-40 cm grou In view of the small size of the animals eaten their comparative scarcity in the stomachs of the small lemon soles is remarkable.

The coelenterates, represented chiefly by the anthozoan, *Cerianthus*, resemble the molluscs in bein more frequently consumed by the larger lemon soles. Volumetrically the increase in this case is mo marked than the frequency percentages indicate, since many of the frequency records for the small fish refer to hydroids, the volumes of which are negligible in comparison with the volumes of anthozoan devoured by the larger fish.

Among the subsidiary food types increasing size in lemon soles is accompanied by a growing interes in nemerteans as food while a definite decline is registered in the case of gephyreans. The ascidians almost wholly confined to the area south of Rattray Head, are interesting because the frequency figure decrease with increasing size of the fish while the volumes remain the same or even tend to increase This is due to the presence of ascidian larvae in the stomachs of the small fish, and of larger adult form in the stomachs of the large fish.

Seasonal Changes in the Food

Seasonal changes have been observed in the food of several food fishes. In order to ascertain whether th food of the lemon sole exhibits any seasonal variations certain well sampled localities have been considered individually.

In the Firth of Forth, where investigations covered a number of bays and rather deeper water positions sampling was carried on in January and from April to October inclusive. In each month, with the ex- ception of January when the fish were not feeding, polychaetes constituted the bulk of the lemon sole food with decapods, chiefly hermit crabs, and gasteropods next in importance. It is also interesting to

note that ascidian larvae, which are conspicuous in the stomachs from Aberlady Bay, were identified in each of the four months, April, May, September and October, in which that locality was sampled. Apart from minor variations in the frequencies with which these and other less important types were eaten, no change in the types of food was observed throughout the months covered by the investigations.

Rectangles C13 and C14, adjoining the Aberdeenshire coast (Figure 1) were sampled in each month from January to December. In this area polychaetes (represented chiefly by the predominant family on the grounds, the Sabellariidae), anthozoans and ascidians were most prominent in the stomachs and continued to be so during the entire feeding period. Proportions of the different types varied somewhat throughout the year but not to such an extent as cannot be explained by local variations in the bottom fauna.

Grounds off the east coast of Orkney were also well sampled from March to October inclusive. This locality shows remarkable uniformity in its lemon sole food throughout the year. At all times polychaetes, represented almost entirely by the Terebellidae, constitute the bulk of the food. Two species, *Lanice conchilega* and *Thelepus cincinnatus*, have been recognised in the stomachs but very often the contents consist purely of worm tentacles.

Shetland grounds were sampled monthly from February to September. On each occasion the predominant food types were polychaetes (especially Terebellidae, Eunicidae and Aphroditidae) amphipods, small gasteropods and ophiuroids. Although the concentration of these forms varies from place to place within the Shetland area, consequently affecting their proportions in the lemon sole stomachs, no outstanding change in the food is noticeable as the year progresses.

It must be concluded, therefore, that no major seasonal change in the diet of the lemon sole occurs throughout the year. While variations in the frequencies with which the different food types are consumed do occur from month to month, these must be regarded as due to local variations in the bottom fauna and possibly also to sampling. Moreover, such variations are of insufficient magnitude to demonstrate any appreciable change in the composition of the food. Similar results indicating the absence of seasonal changes in the diet of lemon soles have already been referred to in a study of the food at the Faroes (Rae, 1939b).

These conclusions are not so unexpected if the nature of the lemon sole food as a whole is compared with that of other species which exhibit seasonal changes in their diet. The animals preyed upon by lemon soles both in the North Sea and elsewhere are predominantly sedentary in habit. Some, such as sedentary polychaetes, coelenterates and ascidians, are completely so in adult life, while others like hermit crabs, molluscs, echinoderms and gephyreans are only slightly more active. Decapods possessing greater freedom of movement, such as *Pandalus*, *Crangon*, *Portunus*, etc. etc. and fish, such as sandeels, herring and the smaller gadoids, all of which form important items in the diet of many other fishes, are practically of no dietary importance to lemon soles. These features, together with the fact that the lemon sole exhibits no pronounced feeding migrations, seem to explain the absence of any marked change-over in the food types throughout the year.

Feeding Habits

This investigation of the food of the lemon sole has revealed a number of features which appear to throw some light on the feeding habits of the species. The period of heavy feeding during summer which is followed by a decline in the intensity of feeding in the last quarter of the year until a state, possibly bearing some resemblance to hibernation, is reached during December, has already been referred to. The scarcity of empty stomachs during the main feeding season has also been mentioned. In this connection it should be pointed out that a large proportion of the stomachs were collected during darkness. No apparent difference has been detected, however, between the contents of those taken by daylight and those taken during darkness. In each case the quantity and the various stages of digestion of the food in the stomachs were in approximately the same proportions. These results suggest that feeding may go on both by day and by night. Certain anatomical characteristics of the lemon sole seem to lend support to this view—namely the relatively small stomach and the long intestine both of which during the feeding season are seldom completely devoid of food. The principle of "little and often" would, therefore, appear to be characteristic of lemon sole feeding.

Turning to the condition of the food in the stomach, two remarkable features are (1) the small siz of most of the individual items and (2) the scarcity of complete animals. With the exception of sma organisms such as amphipods, chitons, Patellidae, Fissurellidae and young ophiuroids, which collectivel form only a small proportion of the total, most of the lemon sole food consists of parts of animals. Compara tively few complete polychaete worms have been found among the stomach contents compared with th quantity of this type consumed in the form of tentacles, heads and thoracic segments. In some localitie both in Scottish and Faroese waters, the fish prey almost exclusively on the tentacles of the Terebellida Hermit crabs are also represented by the thoracic portion although in this case it is not unusual to find th complete animal in the stomachs. The fragmentary nature of the food is particularly well exemplifie by the molluscan type which, except for the small, shelled forms, consists largely of the feet of gasteropo and the siphons and mantle fringes of lamellibranchs. Another major food type, the anthozoan, Cerianthu is generally represented by the head region with tentacles and occasionally by part of the protective tub

A feature of the fragmentary condition of the food which is rather puzzling is the occasional appearanc in the stomachs of sections of the middle or posterior portions of some worms, polychaete and gephyrean without trace of the head or thoracic region. A possible explanation may be that on those occasions o which a worm or part of a worm is extracted from its tube by a lemon sole, another fish seizes the wriggli posterior end before the first fish has had time to swallow its prey. A similar explanation may also accou for the occasional presence in the stomach of the posterior part only of small eupagurids.

In spite of the importance of polychaetes in the lemon sole diet remarkably few worm tubes ar ingested. The most conspicuous of those which do occur in the stomach contents are the tough, mudd tubes of *Sabella pavonina* and, less frequently, sections of the sand and shell-encrusted tubes of *Lani conchilega*. The relative scarcity of molluscan shells is also a noticeable feature which contrasts sharpl with the quantity of crushed shells frequently found in the alimentary canal of plaice for example.

On general appearance the food of the lemon sole falls into one or other of two groups according whether the various items are fragmentary or complete. Those in the first group, which composes th bulk of the food, include purely sedentary types or types whose movements are much restricted. The animals possess some form of shelter, either self-constructed, such as tubes and shells, or acquired as the case of the shells of hermit-crabs and certain sipunculids. The second and smaller group includ small forms which are swallowed complete with shell or skeleton. These organisms, which are represent by chitons and other small gasteropods (e.g. Patellidae and Fissurellidae) and young brittlestars, show common characteristic in adhering closely to any convenient rock surface.

From the appearance of the food several conclusions appear to be justified. In the first place it is cle that the lemon soles have to move about in search of their food. Secondly, the fish appear to feed on t animals in the first group by snapping at the parts protruding from the tubes or shells. The immedia reaction of the prey to attack by a lemon sole would, naturally, be to withdraw into its shelter, th resulting in predator and prey pulling in opposite directions until the situation is terminated by the fi biting off the portion within its mouth. Thirdly, an attack by a lemon sole on an animal adhering to rock surface would almost certainly force it to cling more firmly, thus necessitating an effort by the fi in dislodging it.

The small size of the lemon sole's mouth clearly limits the size of the individual animals eaten. Ev more significant, however, is the nature of the teeth. These are closely set along both jaws thus providi a continuous edge which is perfectly adapted for a biting function and also for the chisel-like acti required to remove small animals adhering firmly to rock surfaces.

Steven (1930), studying the feeding habits of various fishes, states that the "nipped-off ends of tu colous polychaetes are seldom or never found" in the stomachs of lemon soles and concludes that the lem sole does not bite its food but succeeds in withdrawing the worms complete from their tubes. Moreov the same writer found no trace of lamellibranch siphons etc. in the stomach contents. This may be chara teristic of feeding locally in the English Channel, where Steven procured his raw material, but it certain does not apply generally to the main area of distribution of the species in the north western North Se

The list of animals identified in the lemon sole stomachs is both long and varied. Many of the individu species, however, are of rare occurrence, whereas only a relatively small number of organisms are eat

regularly and in quantity. Thus, although about sixty different species of polychaetes have been recognised in the present investigations, less than a dozen of these worms are common in the stomach contents. Reference has been made elsewhere in this paper to the predominance of the Eupaguridae among the decapod food types and to the frequency with which Caprellidae and Ampeliscidae occur among the amphipods. Complete identification of the molluscan types has often been prevented by the fragmentary condition of the food but in this case too there are indications of the bulk of the food consisting of relatively few species. Similarly, two or three ophiuroids outnumber all other echinoderms. Even among the subsidiary food types a preference for certain species is recognisable. Thus in 112 samples containing gephyreans, *Phasolion strombi* was identified in 108, *Phascolosoma minutum* in 5 and *Aspidosiphon mülleri* in 8, figures which clearly indicate a specialised taste in sipunculids.

These observations show that the lemon sole has definite preferences as regards its food and that, in the event of scarcity or absence of the most favoured types, the species can prey upon a large number of alternatives. This ability to survive on food other than the normal principal types, is illustrated in various ways in the present work. For example, gephyreans were found in 57% of the lemon soles from Nairn Bay and larval ascidians were prominent in the stomachs from Aberlady Bay. Furthermore individual fish have been found to be feeding entirely on such unusual types as hydroids and red algae and finally the rather inexplicable occurrence of sandeels in the stomachs of a quarter of the lemon soles in one sample from the Smith Bank area of the Moray Firth provides evidence of a somewhat similar nature.

A comparison of the lemon sole food list with those of other species within the western North Sea such as haddock (Ritchie, 1937), whiting (Jones, 1954), plaice (Todd, 1915 and Ritchie, 1938), cod (Graham, 1923) and cod, megrim and witch (Rae, as yet unpublished), shows remarkably little overlap of individual items. In general composition the food of the lemon sole bears little resemblance to that of any of the first five species of fish mentioned, although a few animals are common to more than one of the lists. The polychaetes, *Lanice conchilega*, *Owenia fusiformis*, *Sabella pavonina*, for example, are also eaten by plaice and haddock but apparently not to the same extent as by lemon soles. Furthermore, there is some evidence that where these worms do occur in the stomachs of plaice and haddock, lemon soles may not always be present on the grounds and vice versa. Similarly the Eupaguridae are preyed upon by both lemon soles and cod, but whereas all sizes of this type of crab are eaten by cod, only the smallest or youngest forms are taken by lemon soles. It seems probable, therefore, that competition for hermit crabs occurs only for the smallest forms between lemon soles and young codling of from 10 to 20 cm in length. As the distribution of this size of codling in Scottish waters tends to be largely local and coastal, the degree of competition between the two species may be much less than the frequencies in the food lists suggest.

The lemon sole's food list on the other hand closely resembles that of the witch in being predominantly of polychaetes. There, however, the resemblance ends for almost without exception the polychaetes eaten by the lemon sole are different specifically from those consumed by the witch. The explanation of this is of course, the difference in habitat—the lemon sole being mainly a dweller on hard ground, either rocky or gravelly, while the witch is confined almost entirely to areas where the sea floor consists of soft mud.

SUMMARY

Lemon soles feed with varying intensity throughout the year. The main feeding season extends from March to September and is heaviest from April to August. During December feeding is practically at a standstill. The complete nature of the stoppage during December is confirmed by the empty condition of the intestines.

The main feeding season of the lemon sole coincides with the main spawning season. Volumetric measurements of the quantities of food consumed throughout the year reveal a setback in May to the rising intensity of feeding. This may be due to a temporary stoppage of feeding by those fish taking part in the first wave of spawning.

The food of the lemon sole consists of five main types—Polychaeta, Crustacea, Mollusca, Echinodermata and Coelenterata—and six subsidiary types—Nemertea, Gephyrea, Ascidiae, Polyzoa, Pisces and Algae. For this study the Scottish area is divided into four regions based on the nature of the lemon sole

growth. In each of the four regions, covering areas of good and poor growth, the Polychaeta exceed the other types although locally within these regions one of the other types may occasionally be mo prominent in the stomachs. Thirteen families of sedentary and nine of errant polychaetes are represent in the food list, although in widely varying proportions. Within each of the other main types preferen is also shown for certain individual sub-types.

Volumetric analysis of the stomach contents confirms the predominance of polychaetes in the d of the lemon sole and also shows that certain types, for example Crustacea and Echinodermata, a probably less important than the frequency of their occurrence in the stomachs indicates. Other typ such as some of the Mollusca and Anthozoa, on the other hand, provide greater volumes within t stomachs and may, therefore, be of greater importance than the frequencies suggest.

The food of lemon soles varies from place to place and some well-defined changes occur in passi northwards from the zones of good growth to those of poor growth. It is concluded that the growth the species is in part determined by the types and quantities of the food available.

Changes in the diet occur throughout the life of the fish. The different sizes of fish show individu preferences for certain types of food. This is to some extent governed by the size of the animals consum — smaller forms being eaten by the smaller fish and larger forms by the larger fish.

No seasonal change in the food of the lemon sole has been observed in the present study. This chara teristic of the feeding of the species appears to be due to the predominance in the food of sedentary typ or of types exhibiting but slight mobility. The small size of the stomach and the presence of food in it at a times seems to indicate that feeding goes on by day and by night and that meals may be small and freque

The lemon sole has to hunt for its food and the fragmentary condition of much of the stomach conte shows that the species feeds by biting off the exposed parts of the animals preyed upon.

The list of animals found in the stomachs contains a large number of animals, although many occ but rarely. About sixty different species of polychaetes have been identified, of which less than a doz are common. This is also characteristic of the other food types.

The food of the lemon sole is compared briefly with that of other common food fishes in the Scotti area. Although some animals are common to several of the lists, serious competition for the types eat by lemon soles appears to be remarkably small.

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List of Individual Species preyed upon by Lemon Soles

The identification of the various organisms in the lemon sole stomachs has been based on the following authorities Polychaeta, Fauvel (1923-27) and McIntosh (1873-1923); Crustacea, Sars (1895-1928) and Bell (1853); Mollusca, Jeff (1862-69) and Forbes and Hanley (1848-53); Echinoderms, Mortensen (1927) and Gephyrea, Stephen (1934). Works more general character, such as The Cambridge Natural History and Die Tierwelt der Nord-und Ostsee, were also consul

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The following list includes notes on the frequency with which many of the different species occur in the stomachs and g the distribution of each animal on the basis of the statistical rectangles (see Figure 1). Positions within territorial waters indicated in more detail by the name of the particular bay or locality.

Polychaeta

Serpula vermicularis, L.—common; Aberlady Bay, Dornoch Firth, Aberdour and Thurso Bays, Loch Eriboll; A14, 15, B14 to 17, 20; C13 to 15, 20; D14, 19; ZZ16, 17; YY16 to 18; XX14, 17; WW12, 13, 16; VV15.

Hydroides norvegica (Gunnerus)—commonest serpulid in lemon sole food; very wide distribution; Firth of Forth, Berv Coast, Dornoch Firth, Nairn, Burghead and Aberdour Bays, Scapa Flow and East Orkney, Thurso, Naver and St. Mag Bays, Loch Eriboll, Rockall Bank; A14 to 16; B10 to 12, 14 to 18; C10 to 20; D9, 14, 18 to 21; E12, 19, 21; F19; G11; ZZ 17; YY16 to 18; XX13, 16, 17; WW12, 13, 16; VV14.

Pomatoceros triqueter, L.—common; more coastal in distribution; Firth of Forth, Berwick Coast, Cromarty and Dornoch Fir Burghead, Spey and Aberdour Bays, Scapa Flow, East Orkney, Thurso and Naver Bays, Loch Eriboll; A14; B12, 14 to C11 to 14; D19; ZZ16, 17; YY16, 17.

Ditrupa arietina (O. F. Müller)—two records from C20, 21; others from ZZ17; YY18; XX17; WW11, 16; VV11, 14, 1

Placostegus tridentatus (Fabricius)—One record from B18, two from WW13.

Sabella pavonina, Savigny—common; Inner Firth of Forth, Inverness and Dornoch Firths, East Orkney, Loch Eriboll; A 16; B14, 15, 17, 20; C11, 13, 14, 18, 20; D19; E13; ZZ16; YY16; XX11, 14, 16, 17; WW11, 13, 16.

Sabella sp.—Firth of Forth, Moray Firth, Minch; A17.

Chone infundibuliformis, Kroyer—scarce; Dornoch Firth; A15.

Chone duneri, Malmgren—solitary records; B15, 17, 20.

Chone filicaudata, Southern—Dornoch Firth, Thurso Bay; C11, 14.

Chone sp.—Dornoch Firth; A15; B15, 17; YY16; XX11; WW11.

Euchone rubrocincta (Sars)—Dornoch Firth, Loch Eriboll; A15.

Sabellaria spinulosa, Leuckart—very common off Aberdeenshire coast but disappears towards the north; Firth of Forth, A deen Bay, Cromarty and Inverness Firths, Nairn Bay; B10 to 14; C10, 12 to 15; ZZ16 (See Fig. 5a).

Thelepus cincinnatus (Fabricius)—very common over wide area, mainly in medium to deep water; east of May Island, Dor Firth, East Orkney, Dunnet Bay, Loch Eriboll, St. Magnus Bay; A15, 16; B15 to 18; C11 to 16, 18 to 20; D9, 13, 19, 20; 12, 21; G11; ZZ17; YY15, 16; XX14, 16, 17; WW11, 16; VV14.

Lanice conchilega (Pallas)—very common; wider distribution than last species due to greater depth range; Firth of Fo St. Andrews Bay, Aberdeen Bay, Dornoch Firth, Nairn and Aberdour Bays, East Orkney, St. Magnus and Thurso B Loch Eriboll, Kyle of Tongue, St. Kilda Bay; A14, 15, 18; B11, 12, 14 to 18; C11 to 21, D19, 21; E19, 21; G11; ZZ16, YY16; XX11, 16, 17; WW11, 13, 16; VV14.

Amphitrite gracilis (Grube)—one record from mouth of Loch Clash (YY15).

Amphitrite sp.—Dornoch Firth and B15.

Polymnia nebulosa (Montagu)—rare; C13; ZZ16; XX14.

Polymnia nesidensis (Delle Chiaje)—very rare; C12.

Polymnia sp.—Thurso and St. Magnus Bays; C11, 12; XX14, 16.

Nicolea zostericola (Oersted)—Aberlady Bay; A15; B16; XX11.

Pista maculata (Dalyell)—rare; Dornoch Firth; A15; WW13.

Pista sp.—Loch Eriboll and mouth of Loch Clash.

Proclea graffi (Langerhans)—solitary records; A14b; C15; B20.

Amaea trilobata (Sars)—single record; B15.

Lysilla loveni, Malmgren—Dornoch Firth, Loch Eriboll; A14, 15; B15 to 17; C13, 18; D20.

Nicomache lumbricalis (Fabricius)—A14b; B15; C14; G11; XX16.

Nicomache maculata, Arwidsson—A15, B14.

Nicomache trispinata, Arwidsson—B15.

Nicomache sp.—numerous unidentified species; Dornoch Firth, Aberdour Bay, Loch Eriboll, St. Magnus Bay; A14, 15; to 17; C12 to 14, 18, 19; D9, 19; E9, 12; G11; ZZ16, 17; YY16; XX16; VV14.

Maldane sarsi, Malmgren—one record from Firth of Forth (A11d).

Clymene robusta (Arwidsson)—two records; C13.

Clymene lumbricoides, Quatrefages—D20; F19.

Clymene sp.—Rose Ness (Orkney), St. Magnus Bay; A14, 16; B15, 20; C13 to 15; D20; E12; ZZ16; YY16; WW13.

Rhodine gracilior, Tauber—one record; B12.

Asychis biceps (Sars)—single specimen; South Minch (WW13).

Owenia fusiformis, Delle Chiaje—common over wide area; Firth of Forth, Cromarty and Dornoch Firths, Aberdour Bay, Scapa Flow, East Orkney, St. Magnus Bay, Loch Eriboll; A14 to 16; B10, 15 to 18, 20; C11, 13 to 15, 17 to 20; D19, 20; E21 G11; J13; ZZ16, 17; YY15, 16; XX11, 17; WW11, 16; VV11, 14.
Cirratulus cirratus (O. F. Müller)—rare; Moclett Head; B 16; D19.
Cirratulus sp.—one specimen; B15.
Ampharete grubei, Malmgren—common species from coastal waters, rare elsewhere; Firth of Forth, Dornoch Firth, Aberdour Bay, St. Magnus Bay, Naver Bay, Rockall Bank; A14, 15; B10, 12, 15; C13, 14, 18; D20; ZZ16; XX11, 12; WW16; VV11, 14.
Amphicteis gunneri (Sars)—Inner Firth of Forth, Scapa Flow, Inganess Bay, Loch Eriboll; A14b; C18; XX13.
Anabothrus gracilis (Malmgren)—one record; Firth of Forth (B11c).
Sabellides octocirrata, Sars—few; St. Magnus Bay; C13; XX13, 17; WW11.
Melinna cristata (Sars)—Aberlady Bay, Fluke Hole, Inner Firth of Forth, Dornoch Firth; B10, 12; XX14.
Melinna palmata, Grube—few; Aberlady Bay and east of Inchkeith.
Pectinaria auricoma (Müller)—one record; A14b.
Pectinaria belgica (Pallas)—one record; off Cromarty Firth.
Pectinaria sp.—Bass-Fidra, Aberdeen Bay, Dornoch Firth, Naver Bay; C14.
Petta pusilla, Malmgren—Rockall Bank; ZZ16.
Stylarioides plumosa (O. F. Müller)—single record; Dornoch Firth.
Stylarioides sp.—single record C14.
Lepidonotus squamatus (L.)—Bass-Fidra, Inner Firth of Forth; A16; B12; C19; D19; ZZ17; YY17.
Gattyana cirrosa (Pallas)—single records; C12, B17.
Harmothoe sp.—B15; C14; E21; many unidentified Aphroditidae, probably belonging to this genus.
Lagisca extenuata (Grube)—few records; C13; B15, 17.
Halosydna gelatinosa, M. Sars—single record; Loch Eriboll.
Phyllodoce lineata (Claparède)—few; Dornoch Firth; C12, 13; YY16.
Phyllodoce groenlandica, Oersted—Berwick Coast; A15; ZZ16.
Phyllodoce sp.—common; Dornoch Firth, Inganess Bay, Rockall Bank; A15, 16; B12, 15 to 17; C12 to 14, 17, 18; D19, 20; E21; G11; ZZ17; YY16; XX14; WW11.
Eulalia viridis (Müller)—common; Moray Firth, Dornoch Firth, Rose Ness, Kyle of Tongue; A14, 15; B12, 15 to 17; C16, 18, 19.
Onuphis conchylega, Sars—common in northern and north-western waters; Inner Firth of Forth, Fluke Hole, Taracliff Bay, Loch Eriboll, Rockall Bank; A15; B10, 16 to 18, 20; C12, 14 to 16, 18 to 21; D13, 18 to 21; E12, 13, 19, 21; F19; J13; ZZ16, 17; YY16; XX11, 14 16, 17; WW16; VV15.
Hyalinoecia tubicola (O. F. Müller)—common in north and north-west; St. Magnus Bay, Rockall Bank; A15, 16; B12, 14 to 18 C13 to 21; D18 to 21; E13, 19; ZZ17; YY16, 18; XX12, 16, 17; WW11, 16; VV11, 14.
Hyalinoecia bilineata, Baird—with few exceptions confined to north-west and west coast regions; Moclett Head; B15; C20; ZZ16; YY16; XX17; WW11, 16; VV11, 15.
Hyalinoecia sp.—C14; WW16.
Eunice pennata, O. F. Müller—northern and north-western form; C18, 20; D19; E19; ZZ17; XX17; WW16; VV14.
Eunice sp.—D19; ZZ16.
Lumbriconereis impatiens, Claparède—one record; Dornoch Firth.
Lumbriconereis sp.—ZZ16; YY16; XX17.
Nereis zonata, Malmgren —B15, 16, 18; C11, 12; G11; ZZ17.
Nereis pelagica, L.—one record; C11.
Nereis fucata (Savigny)—one record; C12.
Nereis sp.—Burghead Bay, East Orkney, Loch Eriboll; A15, 16; B11, 15, 16, 18; C11, 12, 14, 15, 18; D13, 19; ZZ16, 17; WW12
Platynereis dumerilii (Audouin and M.-Edwards)—one record; Nairn Bay.
Syllis armillaris, Malmgren—B15; E21.
Syllis sp.—Firth of Forth; B15, 16, 20; C13 to 15, 18 to 20; D19, 20; E21; ZZ16, 17; YY15, 17; XX13, 17; WW15.
Nephthys sp.—few; Largo Bay, Dornoch Firth, Loch Eriboll; A15.
Ephesia gracilis, Rathke—single record: Dornoch Firth.
Glycera sp.—few; Firth of Forth, Aberdeen Bay, Dornoch Firth, off Sutors.

Crustacea

Eupagurus sp.—this genus, the most prominent of the Decapoda in the lemon sole food, is eaten in all areas but reaches its maximum importance south of Rattray Head.
Galathea sp.—Spey and Dunnet Bays; B12, 15, 16; C11, 12, 14, 16, 17, 19, 20; D19, 20; ZZ16; XX16, 17; WW15.
Hyas sp.—few; Dornoch Firth; A15; B15; C14; ZZ17; YY17.
Portunus sp.—few; Berwick coast, Moclett Head; B11, 12, 15; C14; ZZ17; YY15; WW11.
Ebalia sp.—rare; Rockall Bank; B17; YY17; WW12.
Atelecyclus sp.—rare; XX17; WW15; VV14, 15.
Porcellana longicornis (Pennant)—Berwick coast.
Pandalus sp.—rare; Firth of Forth, Thurso Bay; B17.
Crangon sp.—rare; Berwick coast, off Cromarty; A14; B14; C13, 14; XX17.
Nika sp.—single record; Dornoch Firth.
Gnathia maxillaris (Mont.)—both adult and larval forms; Loch Eriboll; B14.

Gnathia sp.—fairly frequent, many probably *G. maxillaris;* Nairn Bay, off Sutors, Loch Eriboll; B15, 19; C13, 20; E21; F16; XX16, 17; WW11.
Idothea sp.—single record; St. Kilda Bay.
Astacilla sp.—very rare; C18; WW13.
Eudactylina sp.—a few records; B16; YY17.
Mychophilus roseus, Hesse—one specimen of this copepod, parasitic on ascidians, was found in the stomach of a lemon sole from Aberlady Bay.
Scalpellum sp.—one record; C13.
Erythropis sp.—a few; XX17.
Meganyctiphanes norvegica (M. Sars)—VV14.
Nymphon sp.—single record; C19.

Mollusca

Natica sp.—B15, 18; C18, 19; D20; ZZ17; XX17; WW15; VV14, 15.
Trochus sp.—St. Magnus Bay, Loch Eriboll; Rockall Bank; A14b; B15, 19; C14, 18; XX17.
Tectura fulva, Müller—chiefly northern and north-western form; B14, 15, 20; C20; D19; YY16, 17; XX13, 14, 17; WW11 to 13; VV15.
Tectura virginea, Müller—rarer than last species; Dornoch Firth, Spey Bay, Inganess Bay, Moclett Head; XX14.
Emarginula fissura, L.—common in north and north-west; Thurso Bay, Rockall Bank; B15, 18, 20; C20; D19; ZZ16; YY17; XX14, 17; WW11, 13.
Emarginula sp.—B14, 15; ZZ16; WW12.
Puncturella noachina, L.—northern and north-western form; Thurso Bay, Rockall Bank; B20; C18, 20; D19; XX17; WW11, 13; VV15.
Velutina laevigata, Pennant—St. Magnus Bay; A16; B14, 16; C11, 14; ZZ16; XX17.
Mytilus phaseolinus, Phillipi—four records of this small species; two from Thurso Bay and one from each of C18 and ZZ16.
Mytilus sp.—traces of mussels occasionally in stomachs.
Solen sp.—few records of young forms; Dornoch Firth; A15; B10.
Pecten sp.—young of this genus eaten over wide area; rarely in large numbers; Dornoch Firth, Copinsay; A18; B14, 17, 19; C14, 18, 19; ZZ16; YY17; XX13, 15; WW11, 15.
Montacuta sp.—single record; YY17.
Spisula elliptica (Brown)—very rare; XX17; WW15.
Tellina sp.—very rare; Dornoch Firth.
Saxicava sp.—very rare; C12; WW12.

Echinodermata

Ophiura affinis, Lutken—commonest ophiuroid in lemon sole food; Berwick coast, Dornoch Firth, Loch Eriboll, St. Kilda Bay; B12, 15, 17, 18, 20; C11, 13, 14, 16, 18 to 20; D19; ZZ16, 17; YY16; XX17; WW11, 12; VV14, 15.
Ophiura albida, Forbes—fairly common; Berwick coast, Loch Eriboll, Rockall Bank; A15, 18; B15 to 17, 19; C13, 14, 20; D19; ZZ17; YY17; XX16; WW16; VV15.
Ophiura robusta, Ayres—rare; A18; C20; D19.
Ophiura sp.—Dornoch Firth, Rockall Bank; B15; C19; D19; ZZ17; YY17; VV15.
Ophiactis balli (Thompson) –fairly common; B14, 15; C12 to 15, 18 to 20; D19; ZZ16, 17; YY16, 17; XX17; WW11.
Ophiocomina nigra, Abildgaard—single specimen; A18.
Amphiura sp.—rare; C13, 14, 20.
Ophiopholis aculeata (L.)—Thurso Bay; A18; B15, 17; C14; D19; ZZ16, 17; YY17; XX17; WW16.
Amphipholis squamata (D. Chiaje)—rare; A18; B15, 20; E21.
Ophiothrix fragilis (Abildgaard)—single record; B11b.
Echinus sp.—single record of young form; B15.
Echinocyamus pusillus (O. F. Müller)—single records; B17; C14, 18, 19; D19; ZZ16; WW15.

Coelenterata

Cerianthus sp.—very common in parts of Moray Firth and Central North Sea; east of May Island, Aberdeen and Cove Bays, Cromarty and Dornoch Firths, Spey, Burghead and Aberdour Bays, Scapa Flow; A14, 15; B10, 11, 14; C11, 13 to 16; D9 to 11, 14, 18; E9, 12, 13; F14, 16; G11; ZZ16.
Tubularia sp.—recognised from one stomach WW13, but probably eaten more frequently.

Gephyrea

Phascolion strombi, Montagu—very common; Firth of Forth, Aberdeen Bay, Dornoch Firth, off Cromarty Firth, Nairn and Burghead Bays, East Orkney, Loch Eriboll, Loch Clash; A14 to 16; B11, 12, 15 to 18, 20; C11 to 15, 17 to 20; D12, 19 to 21; E13, 21; ZZ16, 17; YY16, 17; XX16, 17; WW11, 12, 16; VV11, 14.
Phascolosoma minutum, Keferstein—rare; Copinsay; C17, 18; D20.
Phascolosoma sp.—fragments; B11b, 19, 20; E21.
Aspidosiphon mulleri, Diesing—B19; C17 to 19; WW13; VV14.

Pisces

Ammodytes sp.—Aberdeen Bay, Dornoch Firth, Moclett Head; Loch Eriboll; A15; B15; C13, 14; ZZ17.
Gobius sp.—two records; XX17; YY17; the latter consisting of developing ova.
Liparis sp.—single record; YY16.
Hippoglossoides platessoides (Fabricius)—one larval fish; D19.

TABLE I

Lemon Sole

Percentages of Fish with Empty Stomachs and Empty Intestines

Month	N.W. North Sea south of 59°15′N			North Sea north of 59°15′N and Scottish north and west coasts.		
	No. Examined	% with Stomach Empty	% with Intestine Empty	No. Examined	% with Stomach Empty	% with Intestine Empty
Jan. ..	151	74	70	—	—	—
Feb. ..	138	54	37	14	36	21
Mar. ..	345	14	7	54	17	11
April ..	160	4	1	95	16	5
May ..	342	6	3	244	9	2
June ..	364	6	2	174	7	1
July ..	253	8	1	338	5	1
Aug. ..	369	7	2	381	11	1
Sept. ..	195	13	5	64	22	3
Oct. ..	333	39	22	—	—	—
Nov. ..	254	62	53	5	100	80
Dec. ..	314	97	95	—	—	—

TABLE II

Lemon Sole

Percentages of Fish with Empty Stomachs and Empty Intestines on Local Grounds, 27th November, 1937—5th March, 1938

Week	Statistical Rectangles	No. of Stomachs Examined	% with Stomach Empty	% with Intestine Empty
27 Nov.-4 Dec. ..	C14, B12, B11	41	88	68
5 Dec.-11 Dec. ..	C13, A11	25	96	92
12 Dec.-18 Dec. ..	C12	12	100	100
19 Dec.-25 Dec. ..	C14, C16	24	96	92
26 Dec.-1 Jan. ..	C13, C15	37	95	86
2 Jan.-8 Jan. ..	C13	24	92	96
9 Jan.-15 Jan. ..	C13, D14	12	33	33
16 Jan.-22 Jan. ..	C12, C16	26	73	81
23 Jan.-29 Jan. ..	C16	15	33	20
30 Jan.-5 Feb. ..	B12, D14	24	54	79
6 Feb.-12 Feb. ..	—	—	—	—
13 Feb.-19 Feb. ..	B12, B11	43	58	44
20 Feb.-26 Feb. ..	C20, C14	17	23	12
27 Feb.-5 Mar. ..	B12	10	0	0

TABLE III

Lemon Sole

Volumes of Food Calculated per 100 Stomachs in Different Size Groups

Month	11-20 cm		21-30 cm		31-40 cm	
	No. of Stomachs Examined	Vol. per 100 Stomachs in c.c.	No. of Stomachs Examined	Vol. per. 100 Stomachs in c.c.	No. of Stomachs Examined	Vol. per 100 Stomachs in c.c.
a. N.W. North Sea south of 59°15′N						
Jan. ..	3	0·0	79	6·0	68	34·0
Feb. ..	2	5·0	55	9·8	30	35·3
Mar. ..	78	22·0	143	62·4	36	97·6
April ..	42	36·2	80	91·1	21	177·1
May ..	69	30·1	158	82·7	28	158·6
June ..	100	39·0	191	97·4	58	270·0
July ..	48	60·8	168	121·8	37	228·0
Aug. ..	127	26·9	193	57·9	47	175·5
Sept. ..	29	17·7	101	65·5	54	135·1
Oct. ..	85	18·5	171	44·8	46	116·9
Nov. ..	89	8·7	111	38·9	53	64·6
Dec. ..	34	0·0	186	1·0	97	2·0
b. North Sea north of 59°15 N and Scottish N. and W. coasts						
Mar. ..	15	20·4	7	38·6	13	160·0
April ..	28	32·2	71	57·0	13	234·6
May ..	65	30·5	116	78·0	17	131·5
June ..	77	24·8	107	61·0	17	223·5
July ..	150	28·1	162	68·3	12	170·4
Aug. ..	190	24·1	166	64·1	30	163·5
Sept. ..	27	17·7	30	46·8	6	68·3

TABLE IV

Lemon Sole

Frequency of Different Food Types per 100 Stomachs
March to September

Size Group	No. of Stomachs with Recognisable Food	Percentages										
		P	C.	M.	E.	L.	N.	G.	Z.	A.	F.	Al.
South of Rattray Head												
11-20 cm	66	95	53	26	2	17	6	20	—	17	—	—
21-30 cm	232	93	56	41	7	26	7	15	—	9	+	+
31-40 cm	87	80	61	43	9	34	6	9	1	8	1	—
Moray Firth												
11-20 cm	388	94	45	28	1	16	2	11	—	—	2	2
21-30 cm	781	94	46	37	7	26	4	7	1	+	2	3
31-40 cm	154	79	42	43	6	45	6	6	1	1	1	2
Shetland												
11-20 cm	236	91	61	10	14	5	1	10	—	—	+	+
21-30 cm	314	90	55	26	29	15	5	7	—	1	—	—
31-40 cm	51	92	47	37	18	22	6	2	—	—	—	—
Scottish N. and W. Coasts												
11-20 cm	285	76	76	27	12	5	1	14	+	+	1	2
21-30 cm	299	88	55	49	26	10	4	5	+	1	+	3
31-40 cm	60	92	42	65	22	12	8	—	—	2	2	8

KEY: P. Polychaeta
C. Crustacea
M. Mollusca
E. Echinodermata
L. Coelenterata
N. Nemertea
G. Gephyrea
Z. Polyzoa
A. Ascidiae
F. Pisces
Al. Algae

TABLE V

Lemon Sole

Calculated Volumes of Food per 100 Stomachs with Percentages of the Different Food Types
March to September

	No. of Stomachs Examined	Calculated volume per 100 Stomachs c.c.	Percentages											
			P	C	M	E	L	N	G	Z	A	F	Al.	?
South of Rattray Head														
11-20 cm	71	29·7	58	9	6	+	7	1	8	—	4	—	—	6
21-30 cm	242	72·5	40	6	18	1	24	1	3	—	3	+	—	4
31-40 cm	96	160·4	36	5	12	1	36	+	1	+	4	2	—	3
Moray Firth														
11-20 cm	420	32·8	73	3	5	+	10	+	4	—	—	1	+	4
21-30 cm	832	80·4	70	2	6	+	15	+	2	+	+	1	+	3
31-40 cm	172	180·6	44	6	17	1	30	1	1	+	+	+	+	—
Shetland														
11-20 cm	249	25·3	76	8	4	4	1	+	2	—	—	+	—	5
21-30 cm	329	62·2	74	4	6	6	3	+	1	—	+	—	—	5
31-40 cm	54	165·9	76	3	5	3	8	+	+	—	—	—	—	4
Scottish N.W. and W. Coasts														
11-20 cm	294	27·2	67	17	4	1	1	1	3	+	+	1	+	4
21-30 cm	317	71·9	62	7	17	3	2	1	1	+	1	+	+	6
31-40 cm	63	210·2	60	4	27	2	1	+	—	—	2	+	+	4

KEY: P. Polychaeta
C. Crustacea
M. Mollusca
E. Echinodermata
L. Coelenterata
N. Nemertea
G. Gephyrea
Z. Polyzoa
A. Ascidiae
F. Pisces
Al. Algae
? Unrecognisable

TABLE VI

Lemon Sole

Frequency of Detailed Food Types per 100 Stomachs

By Statistical Rectangle or Combination of Rectangles (see Fig. 1)

All Sizes

ectangle	C13	C12	C11	B12	B11bd	B10b	B11c, A11d	Central N. Sea E. of 1°W.	C14	C15	C16	B14
epth Range (metres)	30-130	51-65	46-62	57	33-65	11-45	11-55	69-93	43-111	64-103	95-122	30-111
onths	1 to 12	1 to 12	8, 9, 10	2, 3, 9,12	4, 7, 10	5, 7, 10	1, 3 to 12	2 to 11	2 to 12	8 to 12	1 to 12	1, 3 to 12
o. of Stomachs with Recognisable Food	116	27	37	56	24	17	188	57	145	34	33	73
ype of Food	%	%	%	%	%	%	%	%	%	%	%	%
olychaeta	90	90	84	80	79	88	90	77	88	85	94	66
Serpulidae	24	33	43	15	33	53	33	23	7	29	6	27
Sabellidae	6	7	16	—	8	6	11	7	6	3	12	3
Sabellariidae	28	26	—	9	8	24	17	—	66	12	—	1
Terebellidae	34	67	43	41	42	18	52	33	33	38	64	12
Maldanidae	15	4	—	4	4	6	3	28	5	24	12	26
Oweniidae	7	—	3	—	—	18	14	5	1	12	—	3
Ampharetidae	5	—	—	5	4	24	14	—	1	—	—	3
Cirratulidae	—	4	—	—	—	—	—	2	—	—	—	—
Capitellidae	—	—	—	—	—	—	—	—	—	—	—	—
Amphictenidae	1	—	—	—	—	—	1	—	1	—	—	—
Chloraemidae	—	—	—	—	—	—	—	—	1	—	—	—
Chaetopteridae	—	—	—	—	—	—	—	—	—	—	—	—
Spionidae	—	—	—	—	—	—	3	—	—	—	—	—
Aphroditidae	13	15	22	11	17	6	23	19	6	18	18	4
Phyllodocidae	9	19	3	5	13	12	1	14	3	9	18	1
Eunicidae	3	7	—	2	—	6	2	18	4	29	37	5
Nereidae	2	22	14	—	13	12	1	12	3	9	—	—
Syllidae	2	4	19	—	—	—	1	—	2	3	—	—
Hesionidae	—	4	—	—	—	—	2	7	—	—	—	—
Nephthydidae	—	—	—	—	—	—	1	—	—	—	—	—
Sphaeroderidae	—	—	—	—	—	—	—	—	—	—	—	—
Glyceridae	1	—	—	—	—	—	1	—	—	—	—	—
rustacea	35	70	65	49	42	82	64	40	38	56	39	36
Amphipoda	19	70	43	9	25	53	44	40	23	47	27	24
Decapoda	18	22	32	40	21	65	45	7	21	6	3	8
Eupaguridae	14	7	19	11	17	24	30	5	6	6	—	5
sopoda	1	4	—	—	—	—	—	2	—	—	6	3
Copepoda	—	—	—	—	—	—	4	—	—	—	—	—
Cirripedia	2	—	—	2	—	6	—	2	3	—	—	3
Mysidacea	—	—	—	—	—	—	—	—	—	—	—	—
Euphausiacea	—	—	—	—	—	—	—	—	—	—	—	—
Pycnogonida	—	—	—	—	—	—	—	—	—	—	3	—
ollusca	22	52	70	27	38	47	36	11	26	12	9	16
Gasterpoda	16	37	49	22	13	29	32	5	20	9	6	14
Nudibranchiata	13	33	5	11	8	12	5	4	6	3	3	3
Chitonidae	2	15	41	11	—	12	1	2	14	3	3	4
amellibranchiata	4	22	57	5	—	18	4	5	5	—	—	4
Cephalopoda	—	—	—	—	—	—	—	—	—	—	—	—
caphopoda	—	—	—	—	—	—	—	—	—	—	—	—
chinodermata	9	11	16	5	4	12	1	—	14	6	9	1
Ophiuroidea	8	11	16	5	4	12	—	—	13	6	9	1
Echinoidea	—	—	—	—	—	—	—	—	1	—	—	—
Crinoidea	—	—	—	—	—	—	—	—	1	—	—	—
steroidea	1	—	—	—	—	—	—	—	1	—	—	—
Holothurioidea	—	—	—	—	—	—	1	—	—	—	—	—
elenterata	34	19	8	11	29	29	11	81	34	41	9	73
nthozoa	34	15	3	4	25	18	5	81	31	35	9	70
Hydroida	—	4	5	7	4	18	6	2	5	6	—	3
lcyonaria	—	—	—	—	—	—	—	—	—	—	—	—
hyrea	6	30	8	2	25	—	16	9	5	6	—	—
nertea	6	7	22	4	4	—	1	5	8	—	—	—
idiae	18	11	—	18	—	—	19	7	3	—	—	1
yzoa	—	4	—	5	—	—	—	—	3	—	—	—
es	3	—	—	—	—	—	—	—	3	—	—	—
ae	—	—	—	—	—	6	1	—	1	—	—	—

TABLE VI (Contd.)

Rectangle	B15	B16bc	B16a, B17ac	B17d	ZZ14d, A14c	A14a	A14bd	A15	A16	A17, 18, B18, 19	C17ab,C
Depth Range (m)	40-100	67-88	11-46	72-84	9-40	20-47	31-70	38-70	30-100	69-151	82-12
Months	3 to 12	1,3 to 11	5, 6, 8	3 to 10	3, 4, 6, 8, 11	3, 6, 8,10	3, 5 to 12	3 to 12	6,7,8,12	5 to 8	3 to 8
No. of Stomachs with Recognisable Food	370	129	163	145	115	171	90	242	48	62	94
Type of Food	%	%	%	%	%	%	%	%	%	%	%
Polychaeta	90	99	94	98	73	91	91	97	88	79	85
Serpulidae	19	24	5	6	15	26	23	12	38	15	14
Sabellidae	8	6	31	11	10	13	4	31	17	6	10
Sabellariidae	—	—	—	—	3	—	—	—	—	—	—
Terebellidae	65	90	71	94	41	59	60	87	58	63	56
Maldanidae	20	6	5	10	—	6	26	14	4	—	2
Oweniidae	13	12	1	3	1	15	14	36	8	5	1
Ampharetidae	2	1	1	—	—	28	8	5	2	—	—
Cirratulidae	1	2	2	—	—	—	—	—	—	—	—
Capitellidae	+	—	—	1	—	—	1	—	2	—	—
Amphictenidae	—	—	1	—	1	1	1	+	—	—	—
Chloraemidae	—	—	—	—	—	1	—	—	—	—	—
Chaetopteridae	—	—	—	—	—	—	—	—	—	—	—
Spionidae	—	—	—	—	2	2	—	—	—	—	—
Aphroditidae	13	41	26	25	25	18	20	10	19	23	5
Phyllodocidae	19	22	9	13	3	24	4	19	13	—	5
Eunicidae	4	5	2	3	1	1	1	2	2	8	21
Nereidae	3	19	4	3	5	1	1	4	13	16	4
Syllidae	3	2	2	2	—	—	—	1	—	—	—
Hesionidae	—	—	—	—	1	1	—	—	2	—	—
Nephthydidae	—	—	—	—	—	1	—	+	—	—	—
Sphaerodoridae	—	—	—	—	—	1	—	—	—	—	—
Glyceridae	—	—	1	—	1	2	—	—	—	—	—
Crustacea	50	42	34	44	63	53	51	37	52	53	68
Amphipoda	35	35	31	36	52	45	41	34	35	42	50
Decapoda	12	4	5	10	18	12	11	4	13	18	22
Eupaguridae	6	2	2	3	5	4	7	2	4	6	7
Isopoda	4	1	1	1	7	1	—	—	—	2	2
Copepoda	1	6	—	—	—	—	—	—	—	2	4
Cirripedia	2	—	—	1	—	—	1	+	4	2	1
Mysidacea	—	—	—	—	1	—	1	—	—	—	—
Euphausiacea	—	—	—	—	—	—	—	—	—	—	—
Pycnogonida	—	—	—	—	—	—	—	—	—	—	—
Mollusca	40	44	45	46	30	34	28	27	58	44	27
Gasteropoda	21	15	17	9	27	22	21	16	45	37	15
Nudibranchiata	2	5	3	3	9	9	7	2	6	15	2
Chitonidae	14	1	2	5	—	5	—	1	27	10	6
Lamellibranchiata	18	21	31	34	1	9	6	6	6	6	9
Cephalopoda	+	—	—	—	—	1	—	+	—	—	—
Scaphopoda	—	—	—	—	—	—	—	—	—	—	—
Echinodermata	8	6	2	11	2	7	1	2	8	35	36
Ophiuroidea	7	6	—	9	—	6	—	2	8	32	36
Echinoidea	+	1	—	2	—	—	—	—	—	—	2
Crinoidea	—	—	2	—	—	—	—	+	—	5	—
Asteroidea	—	—	—	—	—	—	—	—	—	—	—
Holothurioidea	1	—	—	—	2	1	1	—	—	—	—
Coelenterata	16	9	1	10	15	53	31	37	23	18	1
Anthozoa	12	—	—	1	14	53	30	36	8	3	5
Hydroida	4	9	1	10	1	—	1	1	8	16	6
Alcyonaria	+	—	—	—	—	—	—	—	4	—	—
Gephyrea	7	5	3	3	57	6	2	2	4	3	7
Nemertea	4	3	5	1	—	5	3	2	10	10	2
Ascidiae	—	—	1	—	1	1	—	—	—	—	—
Polyzoa	+	2	—	—	—	—	1	—	4	—	—
Pisces	1	—	2	—	—	1	—	10	—	—	—
Algae	+	8	7	17	1	—	—	—	6	—	—

TABLE VI (Contd.)

ectangle	C18a, C19c	C19a	B20, C20, 21	D19	D20, 21	E19,F19	E21, F21, G21	ZZ16	ZZ16	ZZ17	YY16
epth Range (m) ..	73-133	130	108-154	90-168	100-145	95-146	135-150	18-48	38-82	91-112	63-117
onths	3 to 7	7	2 to 7	3 to 9	3 to 9	3, 4, 6, 8	2, 3, 6, 7, 8, 9	7, 8	5, 7, 8	4, 5, 7, 8	4 to 9
o. of Stomachs with Recognisable Food	114	66	74	124	35	18	26	73	77	128	65
ype of Food ..	%	%	%	%	%	%	%	%	%	%	%
olychaeta	96	97	88	93	91	89	100	92	92	90	97
Serpulidae	12	5	21	21	11	22	38	4	39	19	20
Sabellidae	17	5	14	15	6	6	—	18	12	2	18
Sabellariidae ..	—	—	—	—	—	—	—	—	3	—	—
Terebellidae ..	68	85	47	57	49	50	65	67	61	41	60
Maldanidae ..	12	14	3	11	20	6	15	8	4	10	11
Oweniidae ..	9	2	8	15	3	—	4	3	6	2	8
Ampharetidae ..	8	14	4	1	6	—	4	5	4	—	5
Cirratulidae ..	1	—	—	2	—	—	—	—	—	—	—
Capitellidae ..	—	—	—	1	—	—	—	—	—	—	—
Amphictenidae ..	—	—	—	—	—	—	—	3	3	—	—
Chloraemidae ..	—	—	—	—	3	—	—	1	—	—	—
Chaetopteridae ..	—	—	—	—	—	—	—	—	—	—	—
Spionidae	—	—	—	—	—	—	—	—	—	—	—
Aphroditidae ..	26	35	12	31	9	6	31	22	23	28	18
Phyllodocidae ..	7	8	1	15	11	11	12	10	12	6	8
Eunicidae	25	12	36	31	26	72	31	4	10	37	40
Nereidae	1	—	—	2	—	—	—	3	9	3	2
Syllidae	3	2	4	2	11	—	8	3	1	3	—
Hesionidae	—	—	—	3	3	—	—	—	—	—	—
Nephthydidae ..	—	—	—	—	—	—	—	1	—	—	—
Sphaerodoridae ..	—	—	—	—	—	—	—	—	—	—	—
Glyceridae ..	—	—	—	—	—	—	—	—	—	—	—
Crustacea	52	48	48	50	74	50	77	51	58	78	52
Amphipoda ..	47	47	29	37	63	28	73	40	36	66	45
Decapoda	18	3	21	8	26	22	12	21	31	32	17
Eupaguridae ..	4	—	8	5	14	11	4	7	12	13	6
Isopoda	2	2	1	—	—	—	4	3	1	—	2
Copepoda	—	—	—	—	—	—	—	—	—	4	—
Cirripedia	1	—	1	—	—	6	8	—	5	4	5
Mysidacea ..	—	—	—	—	—	—	—	—	—	—	—
Euphausiacea ..	—	—	—	—	—	—	—	—	—	—	—
Mycnogonida ..	1	—	—	—	—	—	—	—	1	—	—
Mollusca	13	6	34	16	9	28	—	44	72	13	20
Gasteropoda ..	10	5	34	15	9	11	—	30	70	4	18
Nudibranchiata ..	4	—	1	2	—	6	—	3	22	1	2
Chitonidae ..	2	—	21	7	—	6	—	4	40	—	12
Lamellibranchiata	4	2	5	2	3	6	—	14	26	2	5
Cephalopoda ..	—	—	—	—	—	—	—	—	—	—	—
Scaphopoda ..	—	—	—	—	—	—	—	—	—	—	—
Echinodermata ..	18	2	41	16	14	11	4	8	35	12	12
Ophiuroidea ..	15	—	41	16	14	11	4	8	34	12	11
Echinoidea	2	—	—	1	—	—	—	—	1	—	—
Crinoidae	—	—	—	—	—	—	—	—	—	—	3
Asteroidea	—	—	—	—	—	—	—	—	—	—	—
Holothurioidea ..	1	2	—	—	—	—	—	—	—	—	—
Tunicata	18	2	9	8	3	33	4	7	10	10	17
Anthozoa	10	—	7	3	—	33	4	—	6	5	11
Hydroida	7	2	—	6	3	—	—	7	4	6	6
Alcyonaria	—	—	—	—	—	—	—	—	—	—	—
Algae	6	8	10	7	23	—	8	14	1	5	2
Spongia	2	5	—	8	—	—	—	—	9	2	5
Foraminifera ..	—	—	—	—	—	11	—	3	—	—	2
Protozoa	—	—	—	—	—	—	—	1	—	1	—
Rocks	—	—	—	1	—	—	—	3	—	1	2
Sand	—	2	—	—	—	—	—	11	1	—	—

TABLE VI (Contd.)

Rectangle	YY17, 18	XX16	XX17	WW16	WW15	VV14, 15	XX14, 15	WW13 XX13	WW12, XX11,12	VV11 WW11
Depth Range (m)	63-137	110-124	70-151	108-136	88	33-165	50-150	69-100	44-185	112-168
Months	5, 7, 8	6, 8	4, 5, 6, 8	4, 5	8	5, 8	4, 5, 8	4, 5, 8	5, 6, 8, 9	5, 8, 9
No. of Stomachs with Recognisable Food	53	29	47	20	47	58	31	21	24	33
Type of Food	%	%	%	%	%	%	%	%	%	%
Polychaeta	70	97	81	95	13	93	68	81	83	82
Serpulidae	25	10	19	30	—	55	23	33	8	24
Sabellidae	—	7	17	25	—	9	29	43	13	18
Sabellariidae	—	—	—	—	—	—	—	—	—	—
Terebellidae	13	76	36	85	—	19	29	29	21	45
Maldanidae	2	38	—	—	—	19	—	14	4	9
Oweniidae	—	—	15	45	—	5	3	—	21	39
Ampharetidae	—	—	2	5	—	10	13	14	21	15
Cirratulidae	—	—	—	—	—	—	—	—	—	—
Capitellidae	—	—	—	—	—	—	—	—	—	—
Amphictenidae	—	—	—	—	—	—	—	—	—	—
Chloraemidae	—	—	—	—	—	—	—	—	—	—
Chaetopteridae	—	—	—	—	—	2	—	—	—	—
Spionidae	—	—	—	—	—	—	—	—	—	—
Aphroditidae	21	52	36	30	6	10	13	5	21	45
Phyllodocidae	—	31	9	—	—	3	6	—	—	9
Eunicidae	4	48	30	50	—	10	10	—	21	48
Nereidae	—	3	—	—	—	—	—	—	8	—
Syllidae	6	—	6	—	4	—	—	5	8	—
Hesionidae	—	—	2	5	—	—	—	—	—	—
Nephthydidae	—	—	—	—	—	—	—	—	—	—
Sphaerodoridae	—	—	—	—	—	—	—	—	—	—
Glyceridae	—	—	—	—	—	—	—	—	—	—
Crustacea	53	70	57	45	98	81	35	48	54	61
Amphipoda	25	35	40	30	98	60	26	48	29	33
Decapoda	30	31	34	10	45	33	3	10	21	39
Eupaguridae	4	17	6	—	6	14	—	—	—	3
Isopoda	4	7	2	—	—	2	3	5	—	3
Copepoda	2	—	—	—	—	—	—	—	—	—
Cirripedia	4	7	9	—	—	2	—	5	—	3
Mysidacea	—	—	4	—	2	—	—	—	—	—
Euphausiacea	2	—	2	—	—	3	—	—	—	—
Pycnogonida	—	—	—	—	—	—	—	—	—	—
Mollusca	55	52	40	35	28	19	29	43	67	45
Gasteropoda	42	38	32	20	17	17	10	24	42	39
Nudibranchiata	2	10	2	10	—	2	—	—	—	—
Chitonidae	30	—	15	10	—	3	6	14	33	15
Lamellibranchiata	9	—	4	5	13	3	16	5	21	3
Cephalopoda	—	—	—	5	—	—	3	10	—	—
Scaphopoda	—	3	2	—	—	—	—	—	—	—
Echinodermata	45	7	26	25	6	21	19	—	38	12
Ophiuroidea	45	7	26	25	4	19	13	—	38	12
Echinoidea	—	—	—	—	2	—	—	—	—	—
Crinoidea	—	—	—	—	—	2	10	—	4	—
Asteroidea	—	—	—	—	—	—	—	—	—	—
Holothurioidea	—	—	—	—	—	—	—	—	—	—
Coelenterata	6	14	9	10	—	7	32	19	17	3
Anthozoa	—	7	6	5	—	7	26	14	17	3
Hydroida	6	10	—	5	—	—	3	5	—	—
Alcyonaria	—	—	—	—	—	—	—	—	—	—
Gephyrea	4	17	4	10	15	22	—	5	13	12
Nemertea	—	3	6	—	—	—	3	—	13	—
Ascidiae	—	—	—	—	—	2	10	—	—	—
Polyzoa	4	—	—	—	—	—	—	—	—	—
Pisces	2	—	4	—	—	—	—	—	4	—
Algae	—	3	—	—	—	—	—	—	—	—

TABLE VII

Lemon Sole

Regional Summaries of Frequency of Detailed Food Types per 100 Stomachs

Area	S. of Rattray H.	Moray Firth	Shetlands	N. & W. Coasts
No. of Stomachs with Recognisable Food	667	1613	613	719
Type of Food	%	%	%	%
Polychaeta	87	91	91	83
Serpulidae	24	17	16	22
Sabellidae	8	14	11	12
Sabellariidae	27	1	—	—
Terebellidae	41	68	61	42
Maldanidae	8	13	9	8
Oweniidae	6	13	7	7
Ampharetidae	6	5	6	5
Cirratulidae	+	1	+	—
Capitellidae	—	+	+	—
Amphictenidae	+	+	—	1
Chloraemidae	—	+	+	+
Chaetopteridae	—	—	—	+
Spionidae	1	+	—	—
Aphroditidae	15	19	22	24
Phyllodocidae	6	15	8	7
Eunicidae	4	4	25	22
Nereidae	5	5	3	2
Syllidae	2	1	3	3
Hesionidae	1	+	1	+
Nephthydidae	+	+	—	+
Sphaerodoridae	—	+	—	—
Glyceridae	+	+	—	—
Crustacea	50	46	55	64
Amphipoda	32	37	44	47
Decapoda	29	9	16	28
Eupaguridae	16	4	6	8
Isopoda	+	2	1	2
Copepoda	1	1	1	1
Cirripedia	1	1	1	3
Mysidacea	—	+	—	+
Euphausiacea	—	—	—	1
Pycnogonida	—	+	+	+
Mollusca	31	36	20	37
Gasteropoda	24	18	16	28
Nudibranchiata	8	4	3	4
Chitonidae	8	6	6	13
Lamellibranchiata	8	15	4	9
Cephalopoda	—	+	—	1
Scaphopoda	—	—	—	+
Echinodermata	7	5	22	20
Ophiuroidea	6	4	21	19
Echinoidea	+	+	1	+
Crinoidea	+	+	+	1
Asteroidea	+	—	—	—
Holothurioidea	+	+	+	—
Coelenterata	27	24	11	10
Anthozoa	24	21	6	6
Hydroida	4	3	5	4
Alcyonaria	—	+	—	—
Gephyrea	10	8	8	8
Nemertea	5	3	4	3
Ascidiae	12	+	+	1
Polyzoa	1	+	—	1
Pisces	1	2	+	1
Algae	1	3	+	1

TABLE VIII

Frequency of Food of Smallest Lemon Soles (6-10 cm) caught by Otter Trawl per 100 Stomachs

Areas	S. Rattray Hd. Moray Firth	Shetlands North-west and West Coasts
Number of Stomachs with Recognisable Food ..	30	65
	%	%
Polychaeta	100	92
Serpulidae	43	60
Sabellidae	7	3
Terebellidae	30	32
Maldanidae	—	5
Oweniidae	10	3
Ampharetidae	—	6
Aphroditidae	7	6
Eunicidae	—	2
Phyllodocidae	3	9
Syllidae	3	2
Crustacea	43	57
Amphipoda	37	38
Decapoda	7	5
Isopoda	—	2
Cirripedia	—	2
Mollusca	23	8
Gasteropoda	—	6
Nudibranchiata ..	—	2
Chitonidae	—	3
Lamellibranchiata ..	23	2
Echinodermata	—	17
Ophiuroidea	—	17
Crinoidea	—	2
Coelenterata	—	2
Hydroida	—	2
Nemertea	—	2
Gephyrea	—	6
Algae	3	—

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